QUADRICOTTERO DA RICOGNIZIONE

Università degli Studi di Palermo
dipartimento di ingegneria unipa

Mobile and Distribuited Robotics

Professore Adriano Fagiolini - Dottor Daniele Caradonna

Carlo Moscato
Angelo Iacono Quarantino

AGENDA

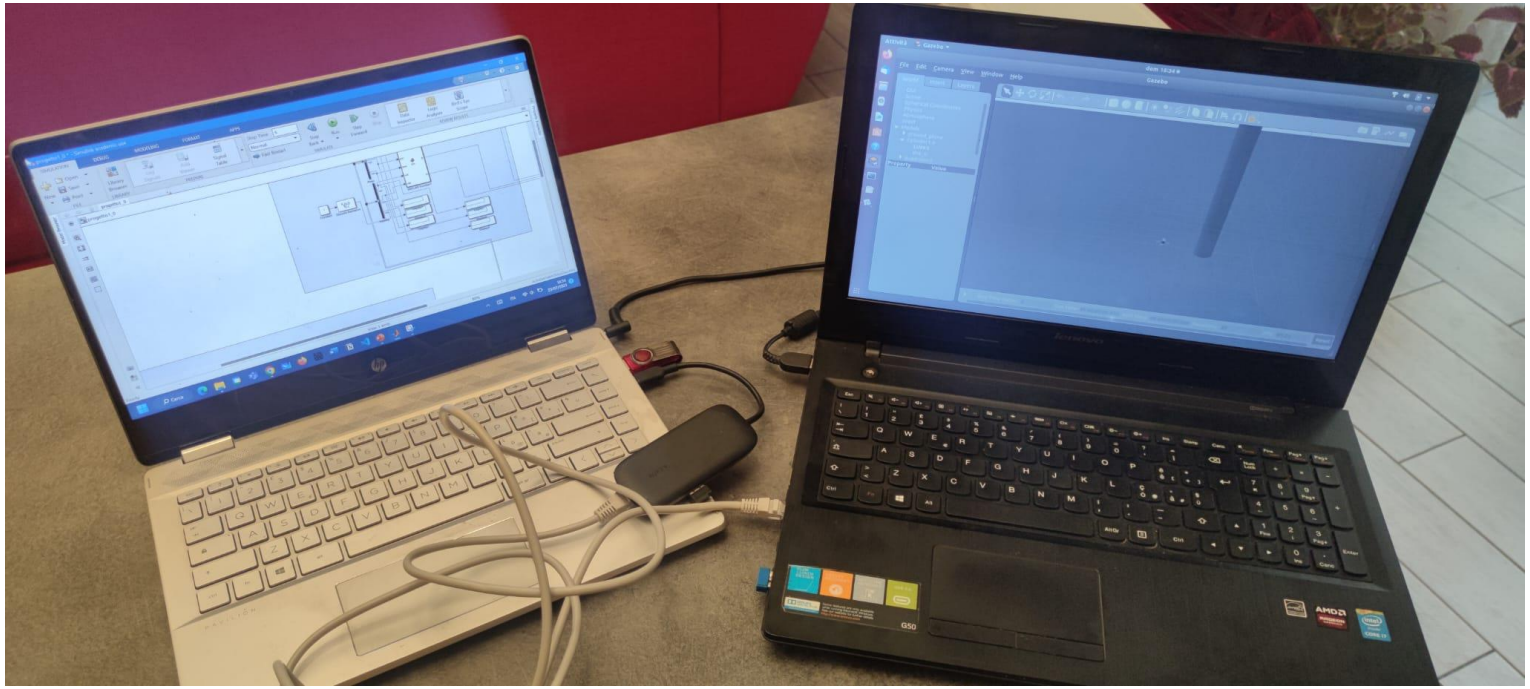
Gazebo

Matlab/Simulink per Gazebo

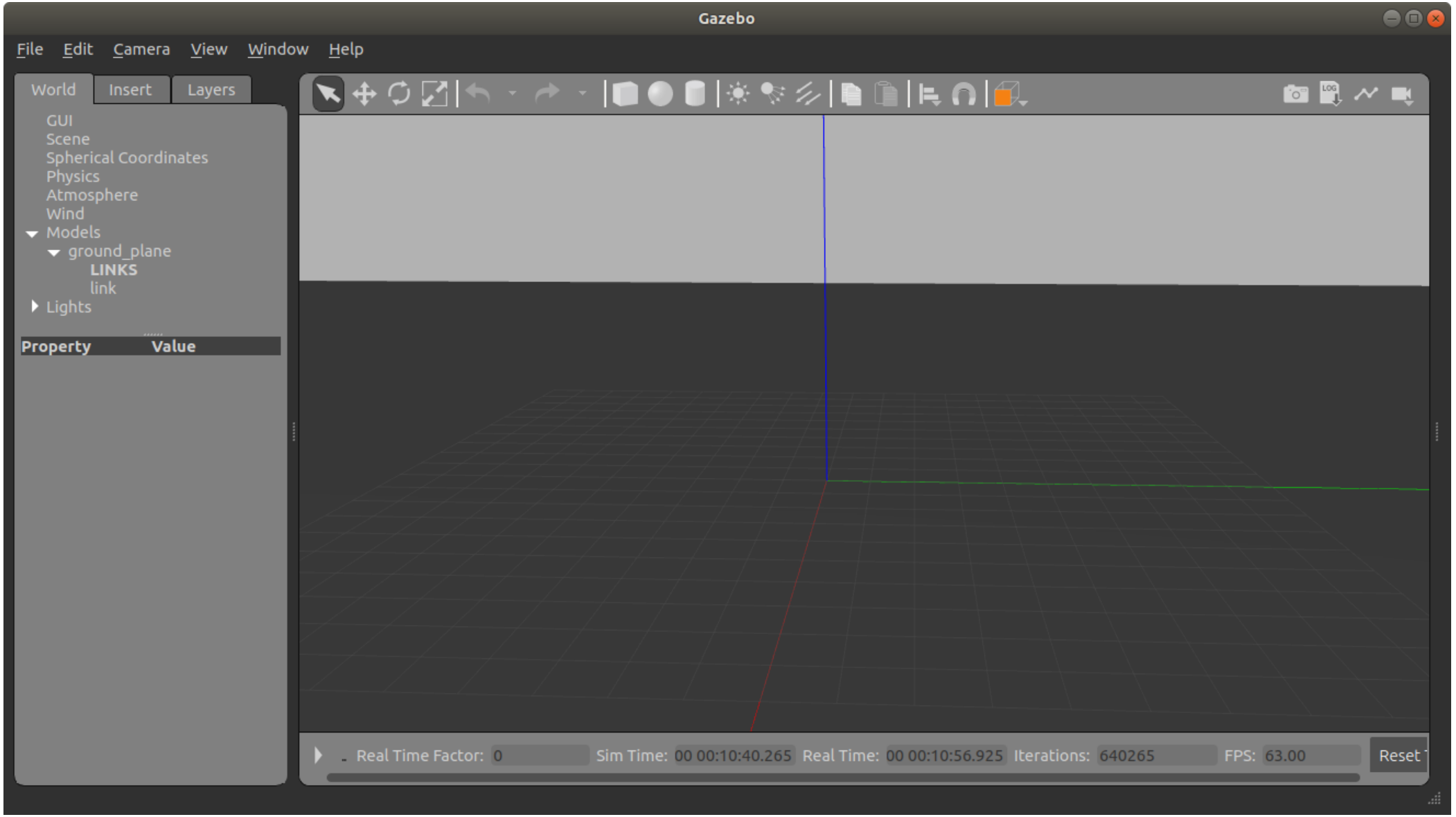
Simulazione e Risultati

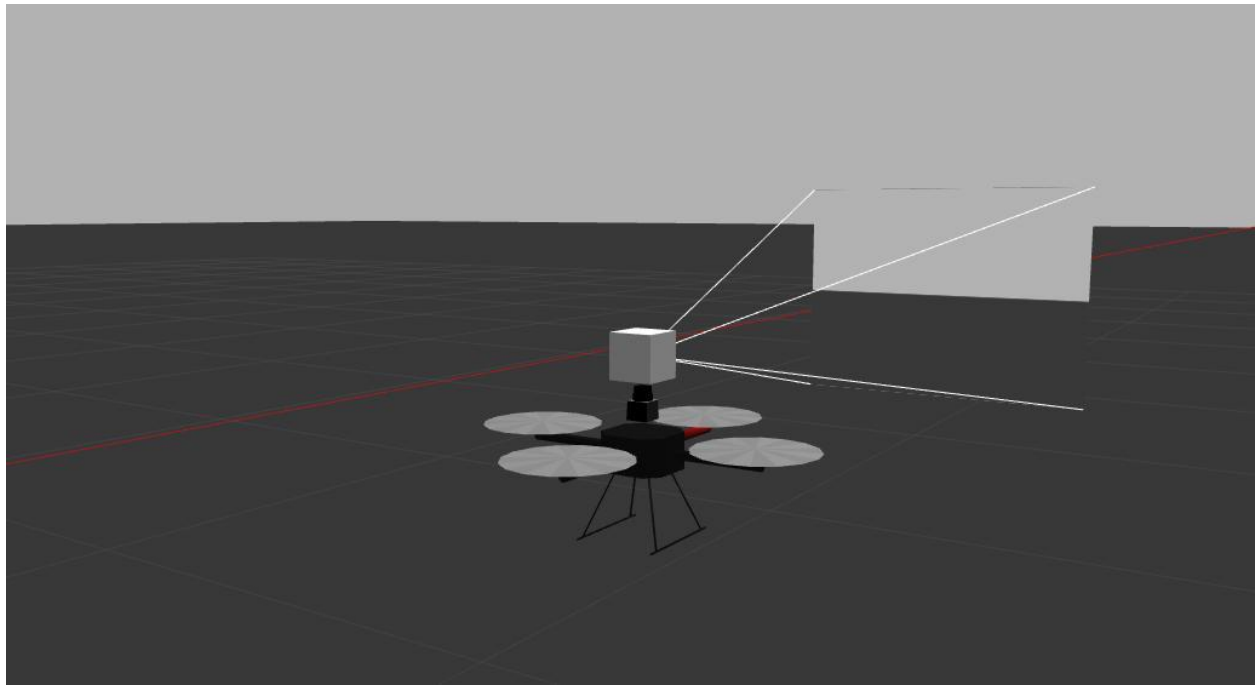
Applicazioni e possibili espansioni nel futuro

- Gazebo9 su Ubuntu 18.04.6 LTS
- Matlab/Simulink su Windows 11
- Collegamento tramite ETHERNET tra due computer per la comunicazione



GAZEBO


Gazebo
File Edit Camera View Window Help
World Insert Layers
GUI
Scene
Spherical Coordinates
Physics
Atmosphere
Wind
Models
ground_plane
LINKS
link
Lights
Property Value
Real Time Factor: 0 Sim Time: 00 00:10:40.265 Real Time: 00 00:10:56.925 Iterations: 640265 FPS: 63.00
Reset

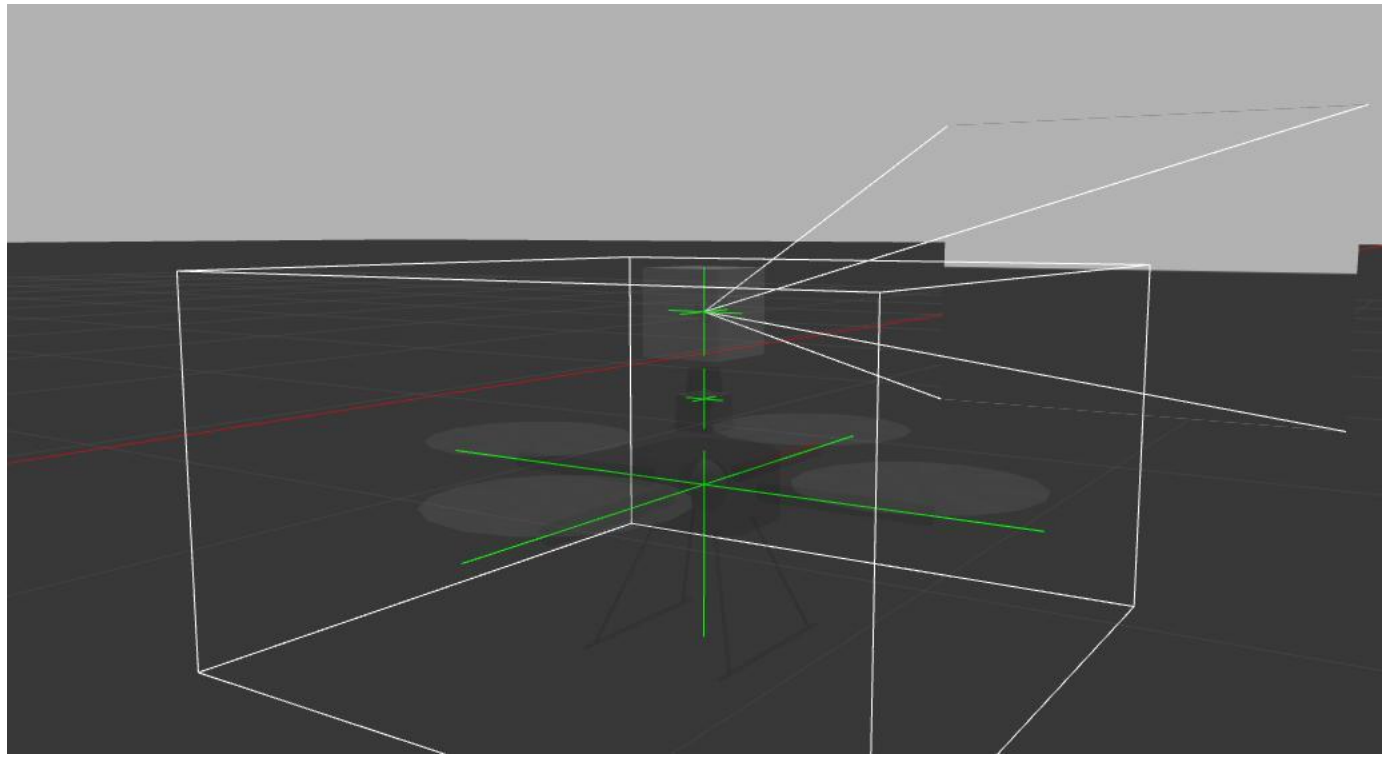


Apri | model.config ~/.gazebo/models/quadrotor_camera | Salva

```
<?xml version="1.0"?>

<model>
  <name>Quadrotor</name>
  <version>1.0</version>
  <sdf version="1.4">model-1_4.sdf</sdf>
  <sdf version="1.5">model.sdf</sdf>

  <author>
    <name>Nate Koenig</name>
    <email>nate@osrfoundation.org</email>
  </author>

  <description>
    A simple quadrotor.
  </description>

</model>
```

XML | Larg. tab.: 8 | Rg 1, Col 1 | INS

- Bug presente nella modalità Model Editor presente in Gazebo9

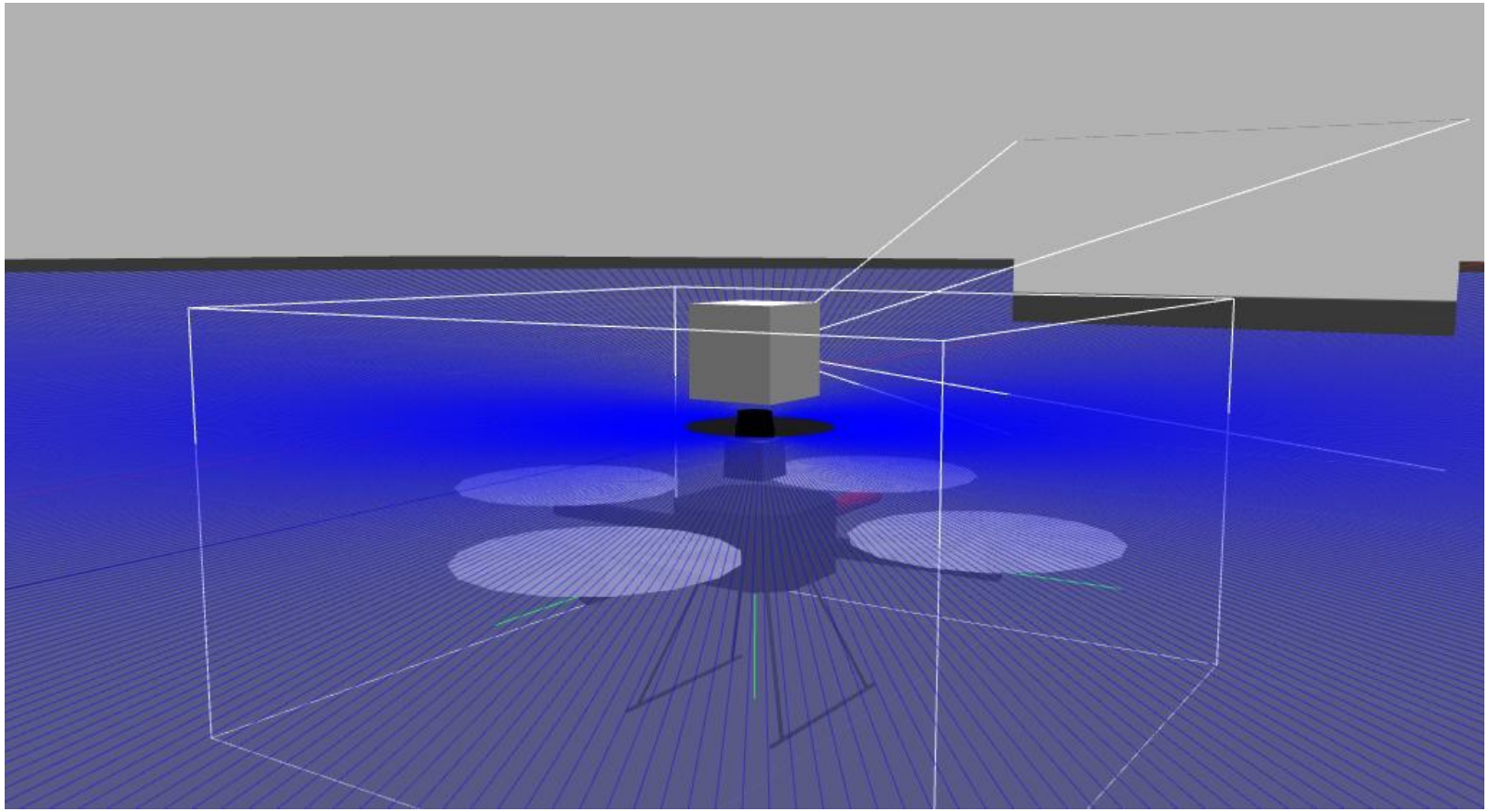


Apri | model.sdf ~/.gazebo/models/quadrotor_camera | Salva

```
<?xml version="1.0" ?>
<sdf version="1.4">
  <model name="quadrotor">
    <link name="link">
      <pose>0 0 0.2 0 0 0</pose>
      <inertial>
        <mass>1.32</mass>
        <inertia>
          <ixx>0.0128</ixx>
          <ixy>0</ixy>
          <ixz>0</ixz>
          <iyy>0.0128</iyy>
          <iyz>0</iyz>
          <izz>0.0218</izz>
        </inertia>
      </inertial>
      <collision name="collision">
        <geometry>
          <mesh>
            <uri>model://quadrotor/meshes/quadrotor_base.dae</uri>
          </mesh>
        </geometry>
      </collision>
      <visual name="visual">
        <geometry>
          <mesh>
            <uri>model://quadrotor/meshes/quadrotor_base.dae</uri>
          </mesh>
        </geometry>
      </visual>
    </link>
    <include>
      <uri>model://hokuyo_drone</uri>
      <pose>0 0 0.3 0 0 0</pose>
    </include>
    <joint name="hokuyo_joint" type="fixed">
      <child>hokuyo::link</child>
```

XML | Larg. tab.: 8 | Rg 1, Col 1 | INS

QUADROTOR



Apri | model.sdf ~/.gazebo/models/quadrotor_camera | Salva

```
        <iyy>0.0128</iyy>
        <iyz>0</iyz>
        <izz>0.0218</izz>
      </inertia>
    </inertial>
    <collision name="collision">
      <geometry>
        <mesh>
          <uri>model://quadrotor/meshes/quadrotor_base.dae</uri>
        </mesh>
      </geometry>
    </collision>
    <visual name="visual">
      <geometry>
        <mesh>
          <uri>model://quadrotor/meshes/quadrotor_base.dae</uri>
        </mesh>
      </geometry>
    </visual>
  </link>
  <include>
    <uri>model://hokuyo_drone</uri>
    <pose>0 0 0.3 0 0 0</pose>
  </include>
  <joint name="hokuyo_joint" type="fixed">
    <child>hokuyo::link</child>
    <parent>quadrotor::link</parent>
  </joint>
      <include>
    <uri>model://camera_drone</uri>
    <pose>0 0 0.4 0 0 0</pose>
  </include>
  <joint name="camera_joint" type="fixed">
    <child>camera::link</child>
    <parent>quadrotor::link</parent>
  </joint>
 </model>
</sdf>
```

XML | Larg. tab.: 8 | Rg 1, Col 1 | INS

LIDAR E CAMERA

Apri | *model.sdf ~/.gazebo/models/hokuyo_drone | Salva

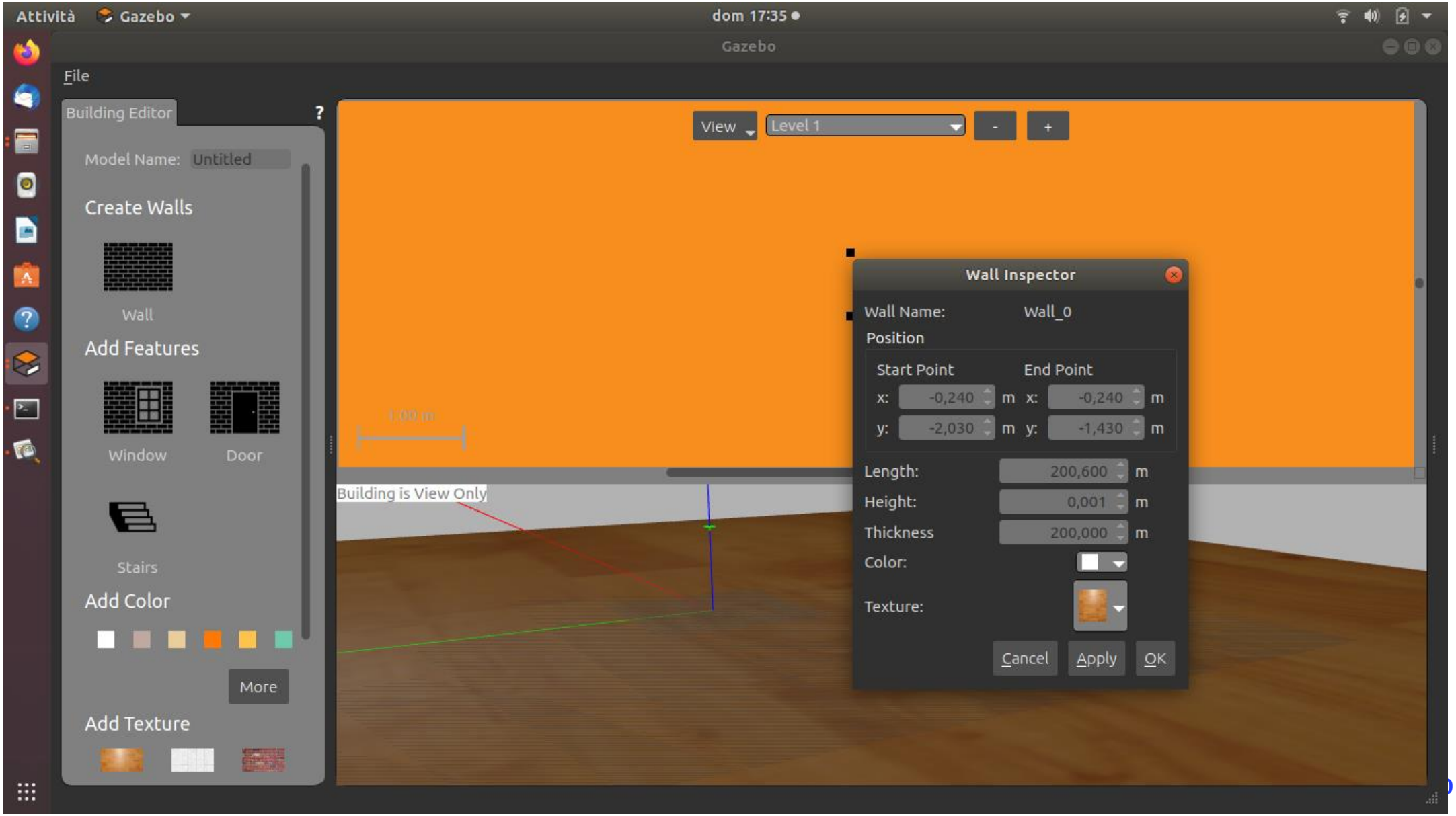
```
        </box>
      </geometry>
    </collision>
    <collision name="collision-top">
      <pose>0 0 0 0 0 0</pose>
      <geometry>
        <cylinder>
          <radius>0.021</radius>
          <length>0.029</length>
        </cylinder>
      </geometry>
    </collision>
    <sensor name="laser" type="ray">
      <pose>0.01 0 0.0175 0 -0 0</pose>
      <ray>
        <scan>
          <horizontal>
            <samples>640</samples>
            <resolution>1</resolution>
            <min_angle>-3.14</min_angle>
            <max_angle>3.14</max_angle>
          </horizontal>
        </scan>
        <range>
          <min>0.08</min>
          <max>10</max>
          <resolution>0.01</resolution>
        </range>
      </ray>
      <plugin name="laser" filename="libRayPlugin.so" />
      <always_on>1</always_on>
      <update_rate>30</update_rate>
      <visualize>true</visualize>
    </sensor>
  </link>
 </model>
</sdf>
```

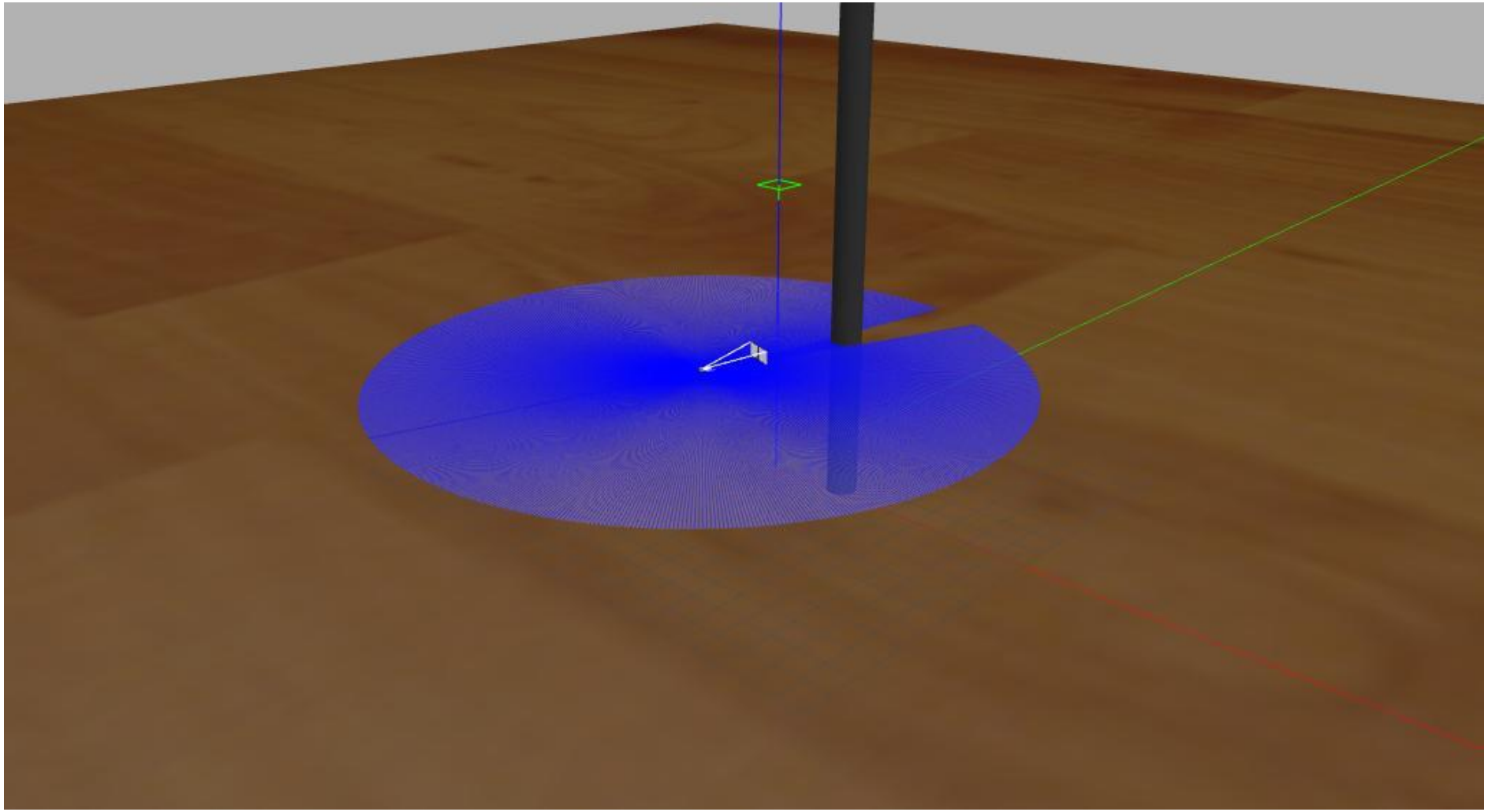
XML | Larg. tab.: 8 | Rg 47, Col 20 | INS

Apri | model.sdf ~/.gazebo/models/camera_drone | Salva

```
        <iyy>0.000166667</iyy>
        <izz>0.000166667</izz>
      </inertia>
    </inertial>
    <collision name="collision">
      <geometry>
        <box>
          <size>0.1 0.1 0.1</size>
        </box>
      </geometry>
    </collision>
    <visual name="visual">
      <geometry>
        <box>
          <size>0.1 0.1 0.1</size>
        </box>
      </geometry>
    </visual>
    <sensor name="camera" type="camera">
      <camera>
        <horizontal_fov>1.047</horizontal_fov>
        <image>
          <width>320</width>
          <height>240</height>
        </image>
        <clip>
          <near>0.1</near>
          <far>100</far>
        </clip>
      </camera>
      <always_on>1</always_on>
      <update_rate>30</update_rate>
      <visualize>true</visualize>
    </sensor>
  </link>
 </model>
</sdf>
```

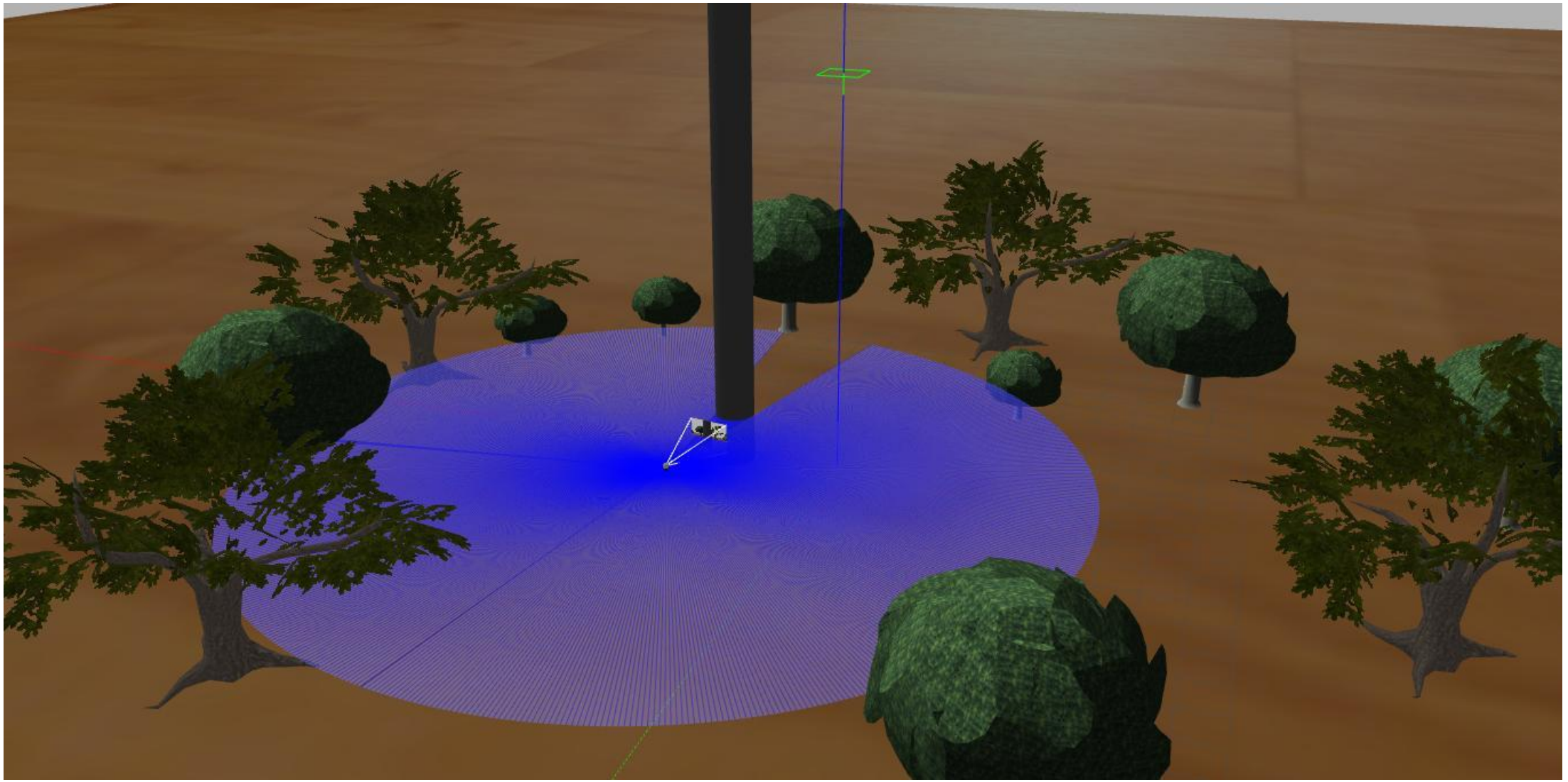
XML | Larg. tab.: 8 | Rg 37, Col 21 | INS


Attività
Gazebo
dom 17:35
Gazebo
File
Building Editor
Model Name: Untitled
Create Walls
Wall
Add Features
Window
Door
Stairs
Add Color
More
Add Texture
View
Level 1
-
+
1.00 m
Building is View Only
Wall Inspector
Wall Name: Wall_0
Position
Start Point
End Point
x: -0,240 m x: -0,240 m
y: -2,030 m y: -1,430 m
Length: 200,600 m
Height: 0,001 m
Thickness 200,000 m
Color:
Texture:
Cancel
Apply
OK

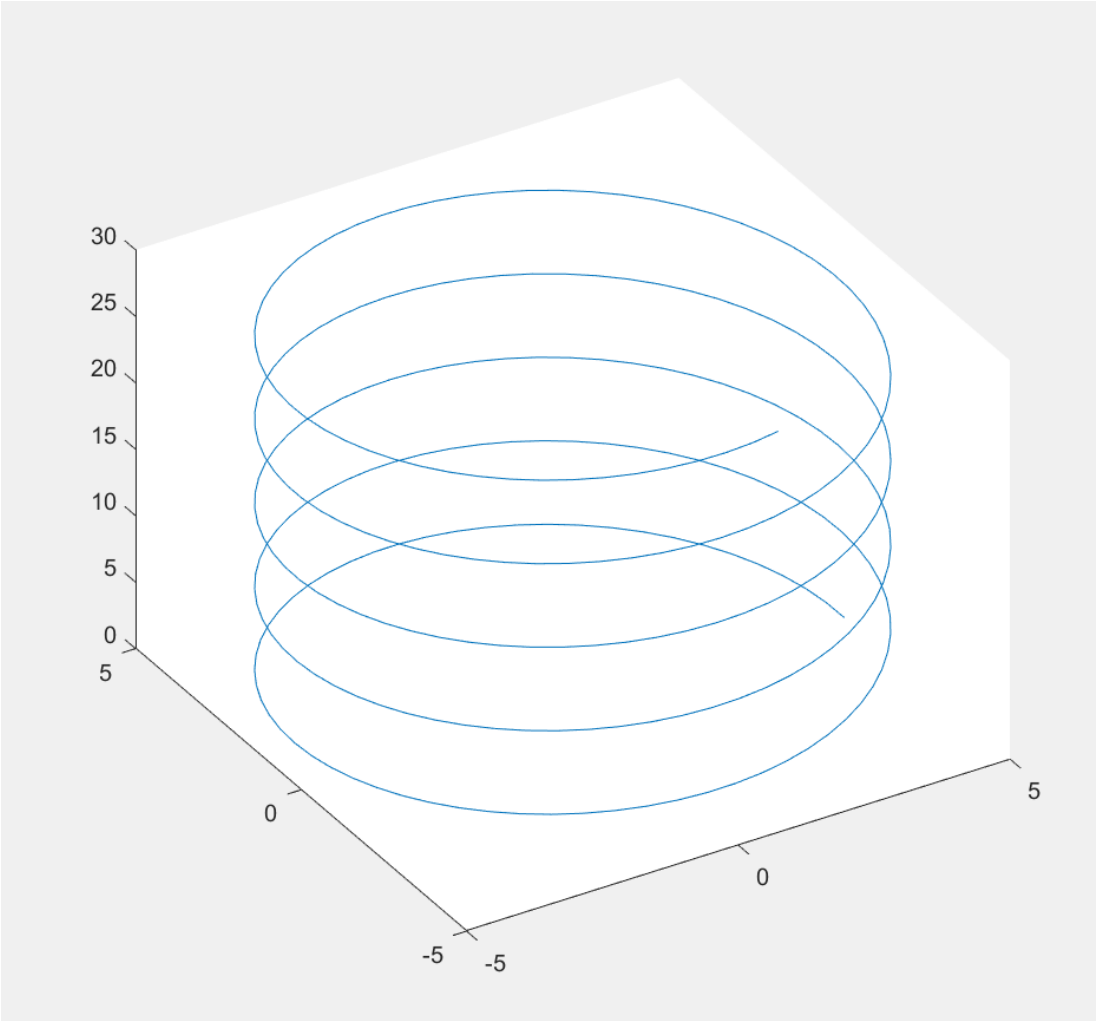


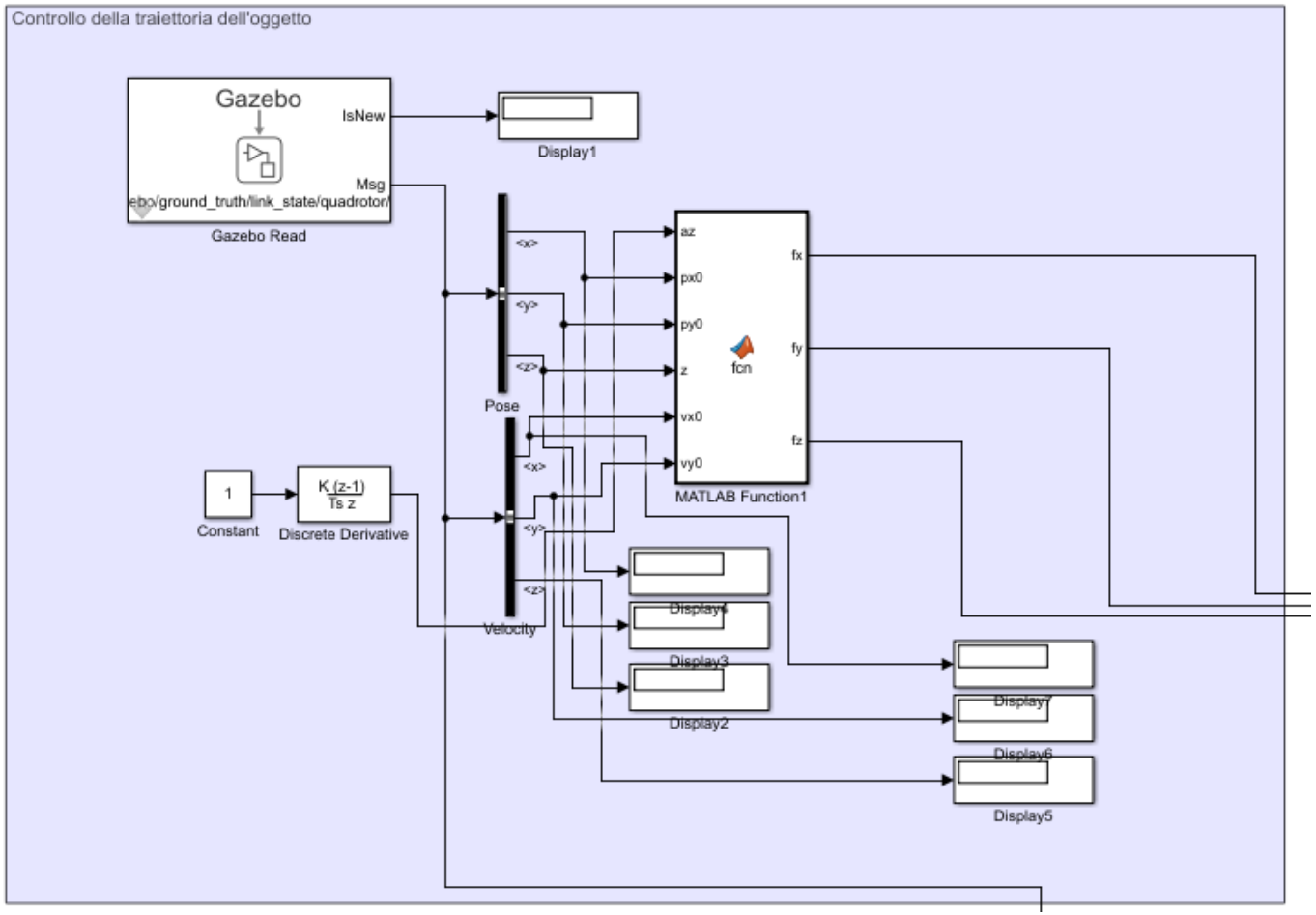
Quadrotor:
Posizione iniziale:
x = 5 m
y = 0 m
z = 0.2 m
Orientazione:
roll = 0 rad
pitch = 0 rad
yaw = 1,39 rad

Cilindro:
Posizione:
x = 2,68 m
y = 0,32 m
z = 0 m
Altezza: 30 m

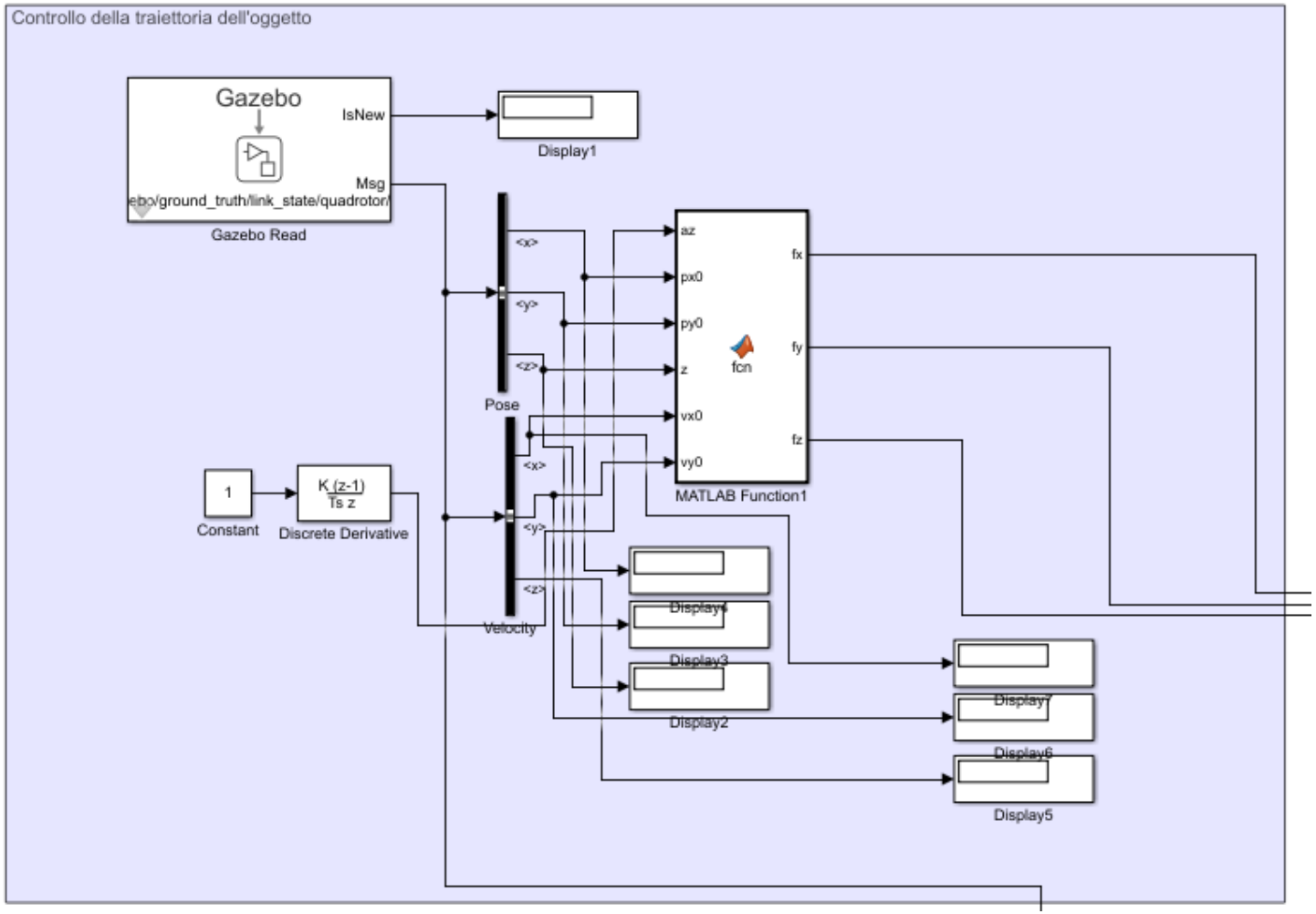


MATLAB/SIMULINK PER GAZEBO


30
25
20
15
10
5
0
5
0
-5
-5
0
5


Controllo della traiettoria dell'oggetto
Gazebo
IsNew
Msg
ebo/ground_truth/link_state/quadrotor/
Gazebo Read
Display1
Pose
<x>
<y>
<z>
az
px0
py0
z
vx0
vy0
fcn
fx
fy
fz
MATLAB Function1
1
Constant
K (z-1)
Ts z
Discrete Derivative
Velocity
Display4
Display3
Display2
Display7
Display6
Display5

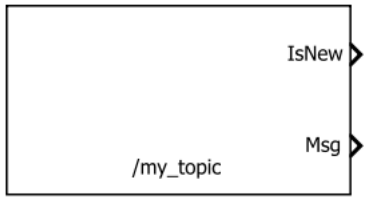
```
function [fx, fy, fz] = fcn(az , px0, py0, z, vx0, vy0)

t = 0.2;
m = 1.32+0.1+0.1;
px = 5*cos(z);
py = 5*sin(z);

ax = (2*(px - (vx0*t) - px0))/(t^2);
ay =(2*(py - (vy0*t) - py0))/(t^2);

% ax = (2*(px  - px0))/(t^2);
% ay = (2*(py  - py0))/(t^2);


fx = ax*m;
fy = ay*m;
fz = m*(9.8+az);
```



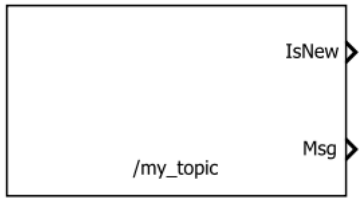
Gazebo Apply Command

Gazebo Blank Message

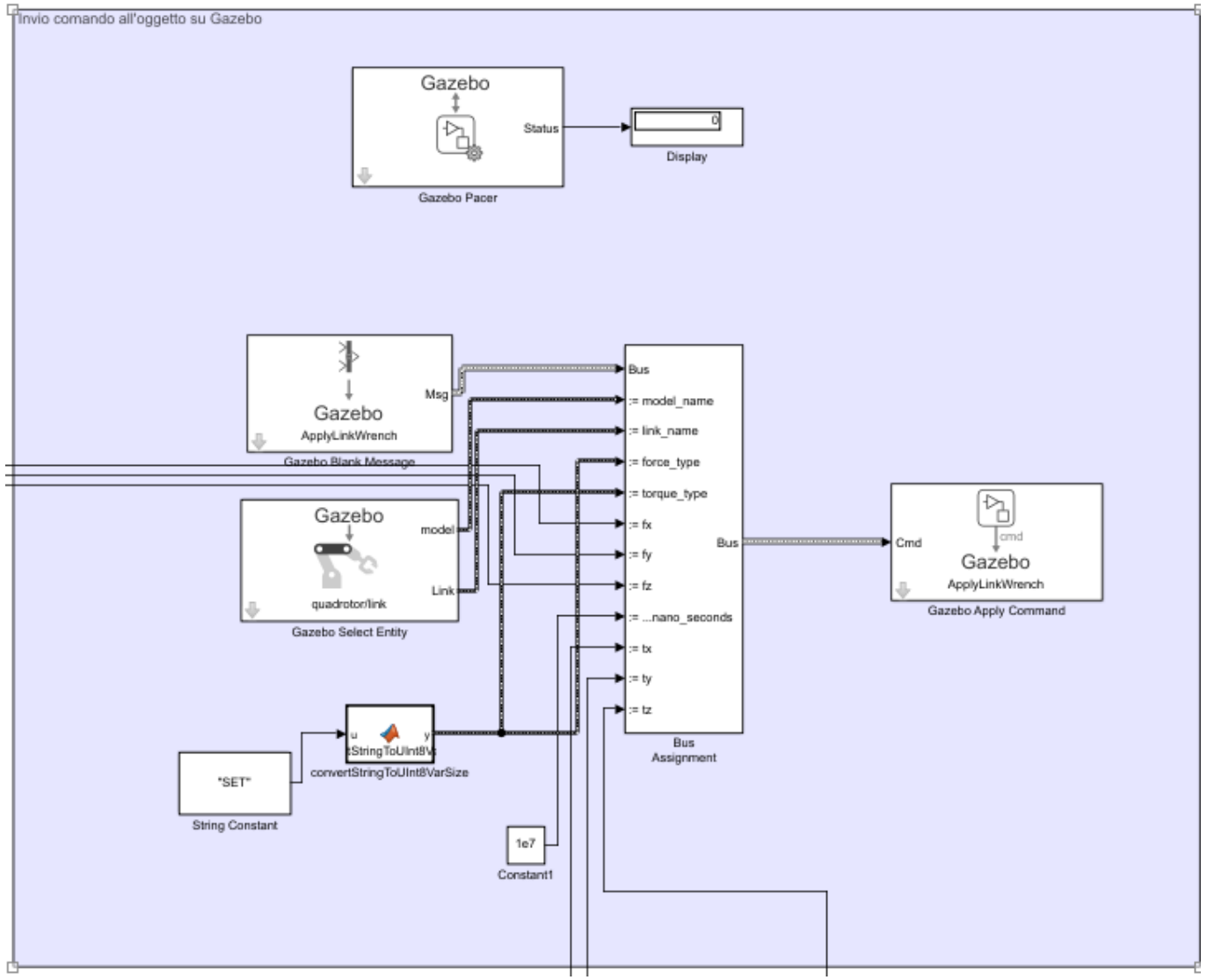
Gazebo Pacer



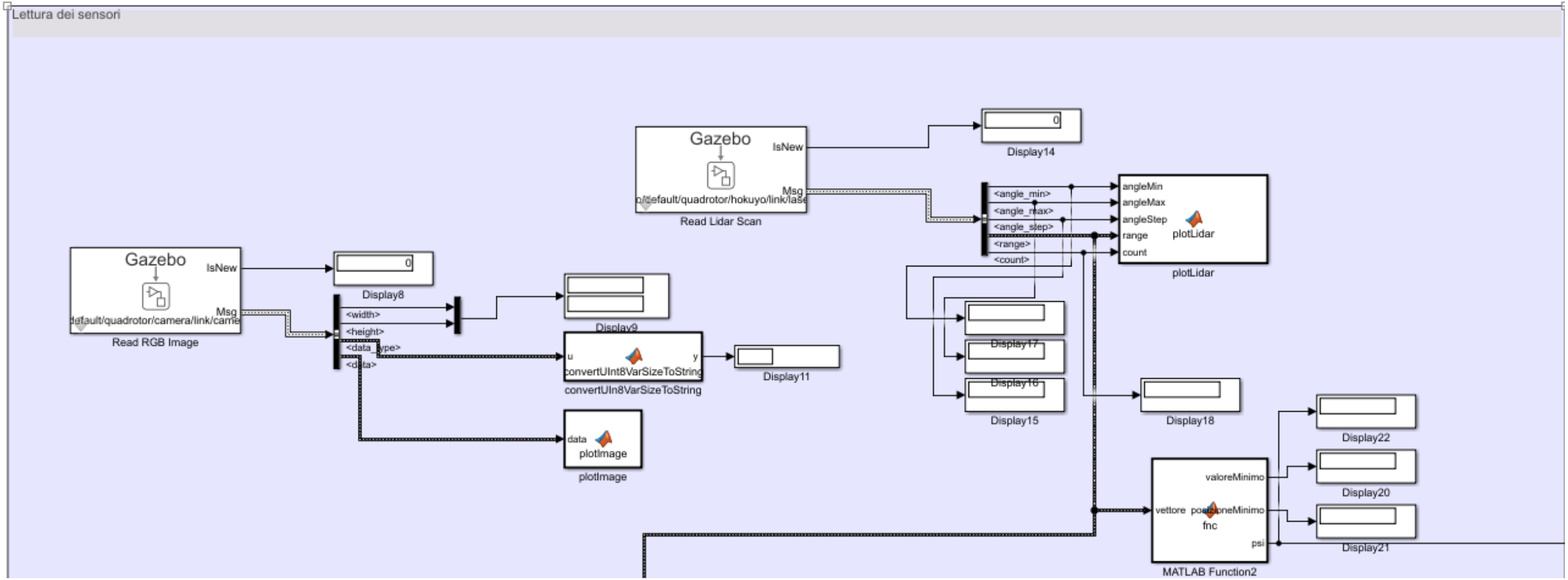
Gazebo Read

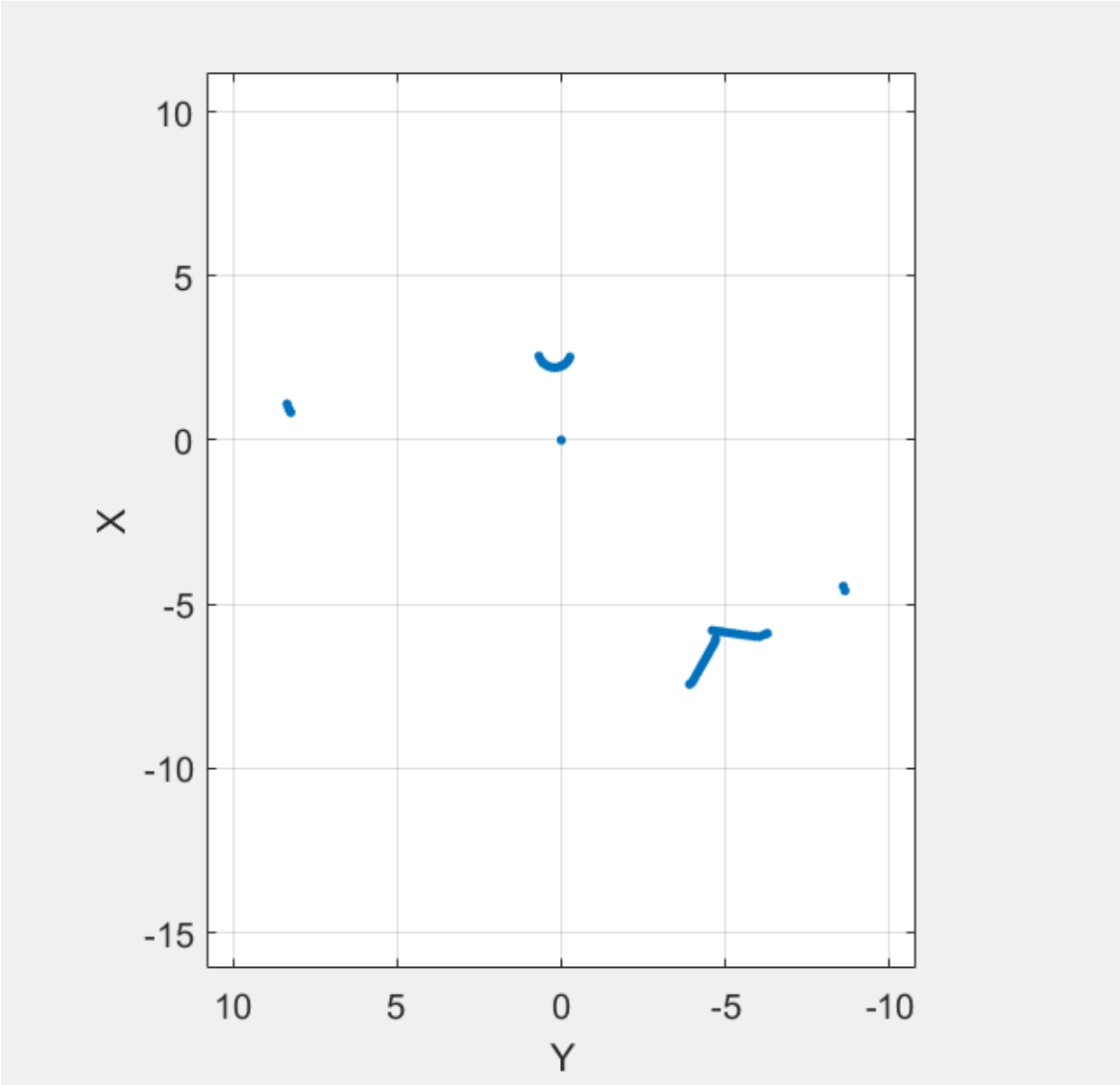


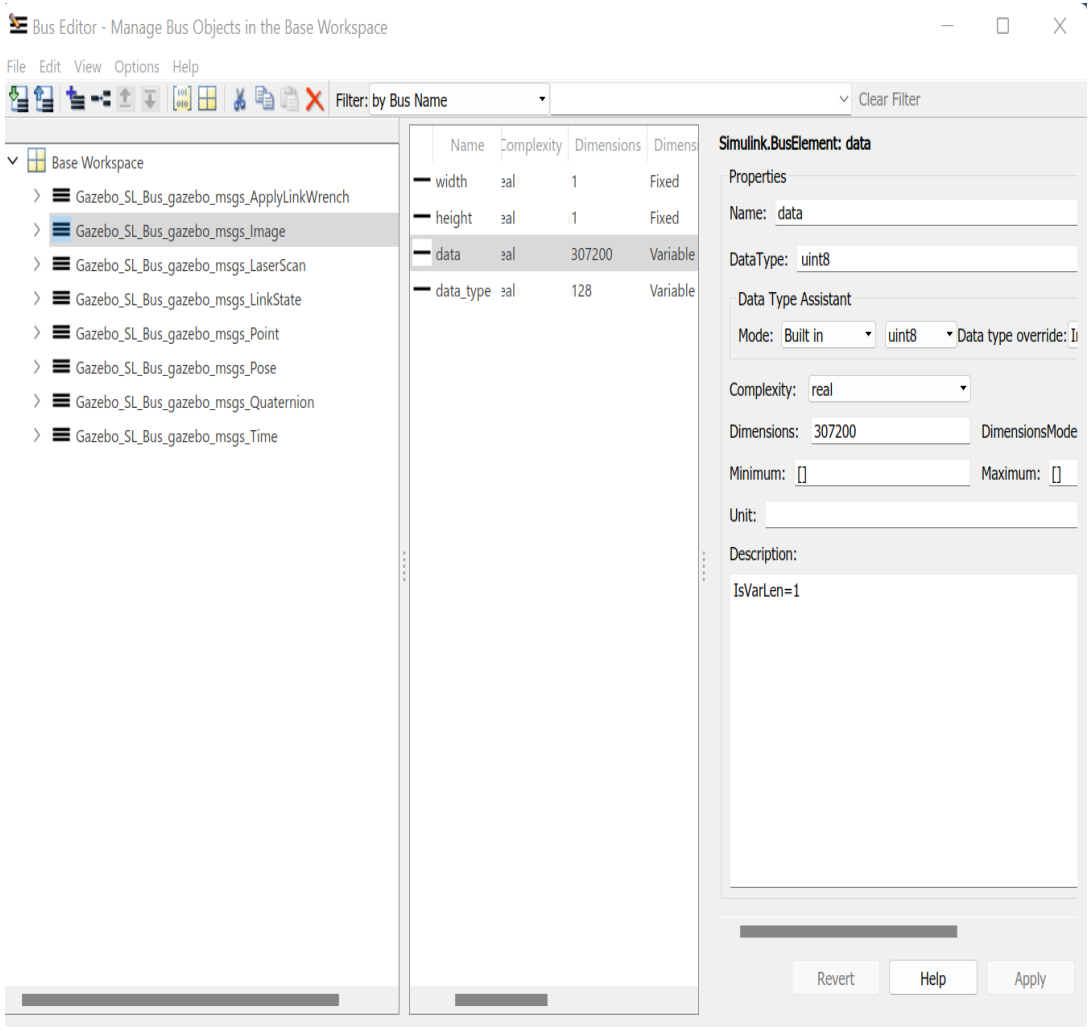
Gazebo Subscribe

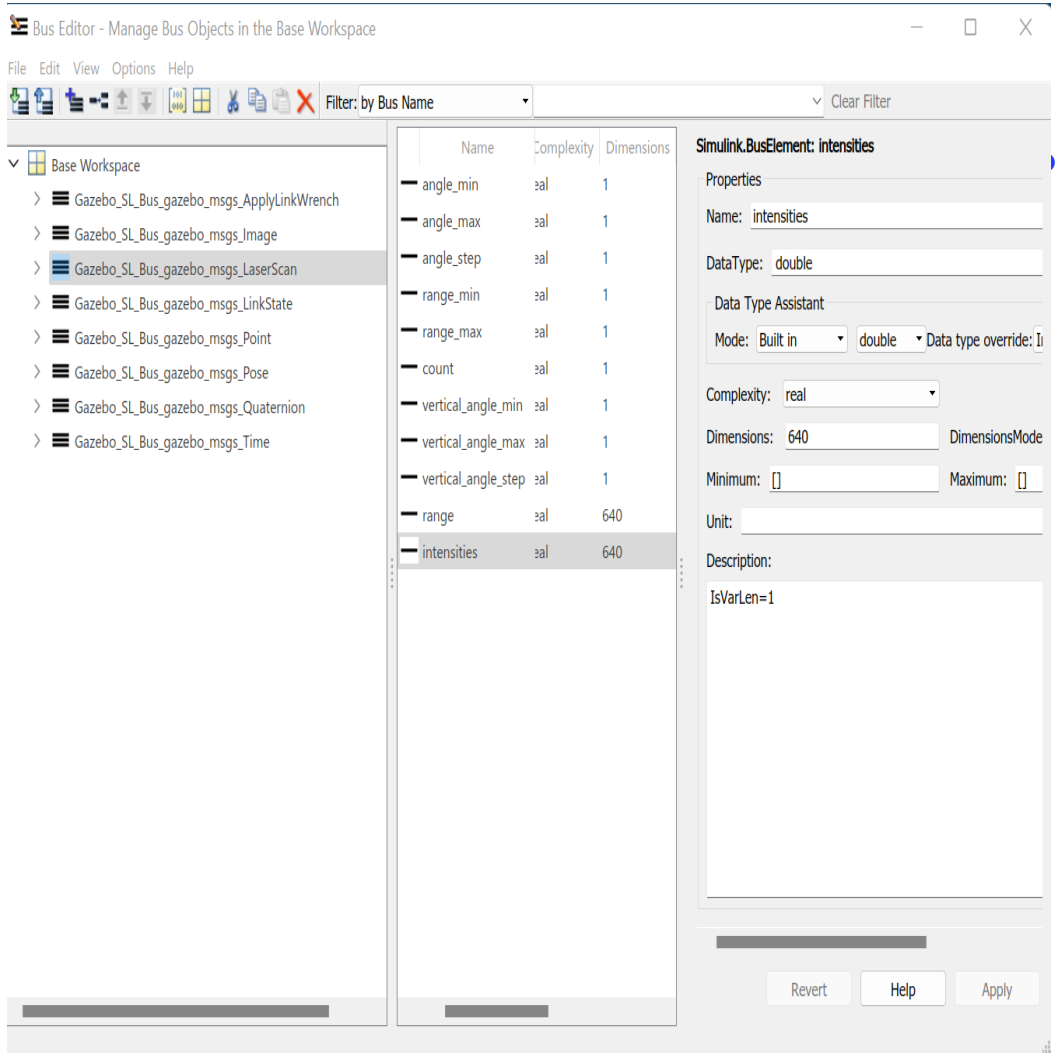


«open_system("performCoSimulationWithGazebo")»

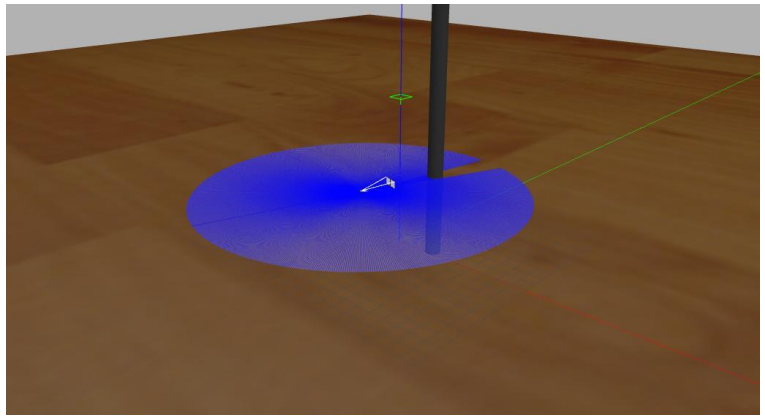


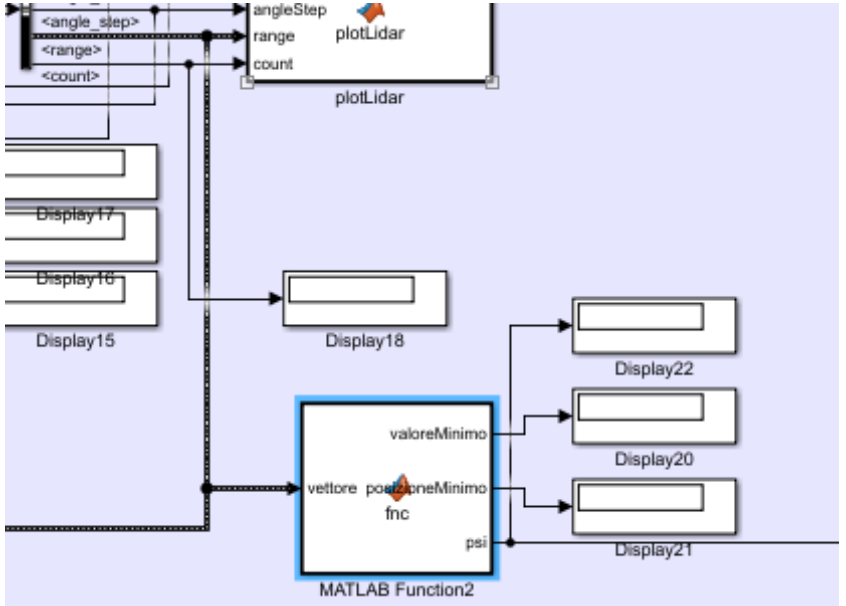

10
5
0
-5
-10
-15
X
10
5
0
-5
-10
Y

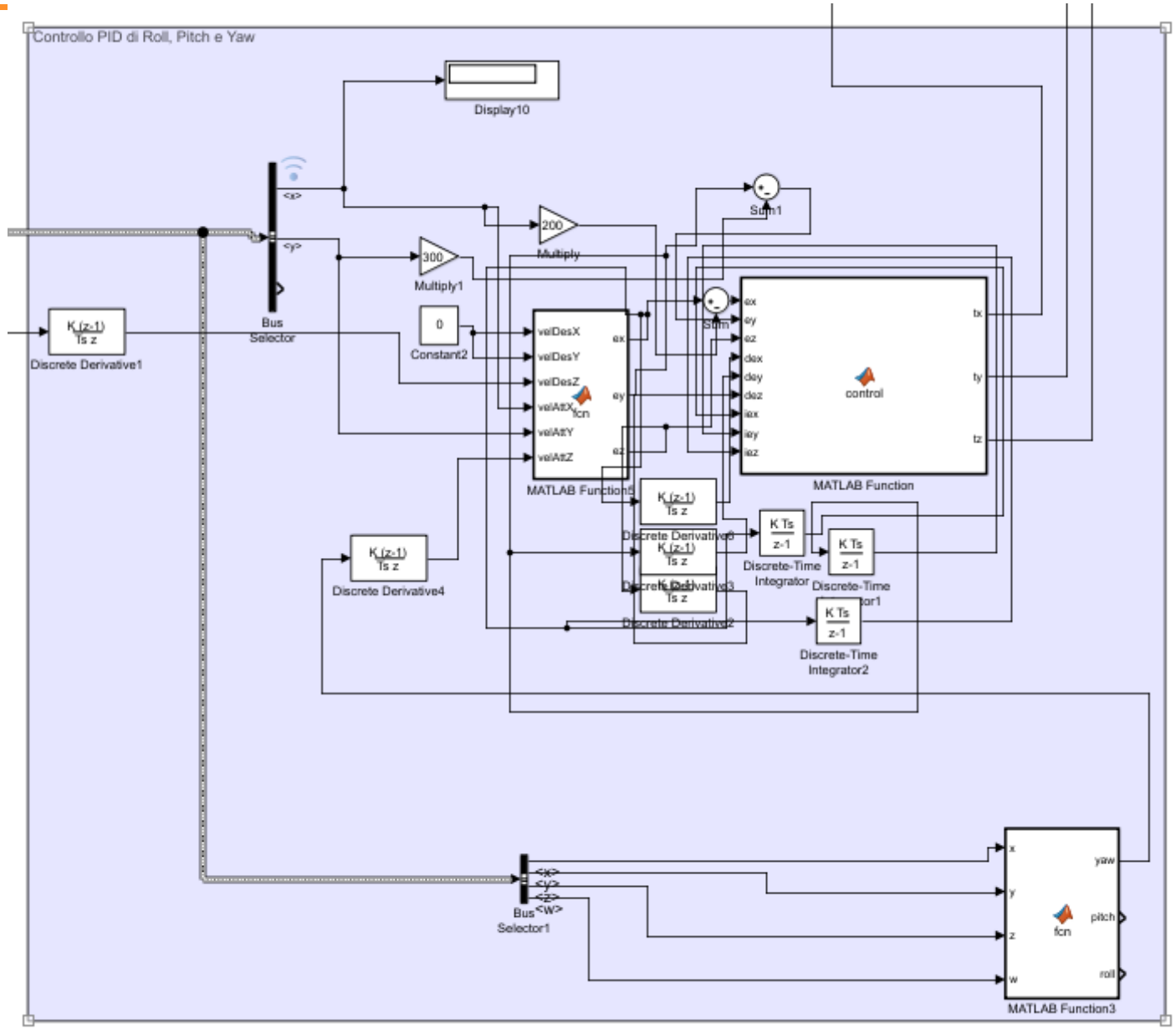

Bus Editor - Manage Bus Objects in the Base Workspace
File Edit View Options Help
Filter: by Bus Name
Clear Filter
Base Workspace
Gazebo_SL_Bus_gazebo_msgs_ApplyLinkWrench
Gazebo_SL_Bus_gazebo_msgs_Image
Gazebo_SL_Bus_gazebo_msgs_LaserScan
Gazebo_SL_Bus_gazebo_msgs_LinkState
Gazebo_SL_Bus_gazebo_msgs_Point
Gazebo_SL_Bus_gazebo_msgs_Pose
Gazebo_SL_Bus_gazebo_msgs_Quaternion
Gazebo_SL_Bus_gazebo_msgs_Time
Name Complexity Dimensions Dimens
width eal 1 Fixed
height eal 1 Fixed
data eal 307200 Variable
data_type eal 128 Variable
Simulink.BusElement: data
Properties
Name: data
DataType: uint8
Data Type Assistant
Mode: Built in
uint8
Data type override: I
Complexity: real
Dimensions: 307200
DimensionsMode
Minimum: []
Maximum: []
Unit:
Description:
IsVarLen=1
Revert
Help
Apply


Bus Editor - Manage Bus Objects in the Base Workspace
File Edit View Options Help
Filter: by Bus Name
Clear Filter
Base Workspace
Gazebo_SL_Bus_gazebo_msgs_ApplyLinkWrench
Gazebo_SL_Bus_gazebo_msgs_Image
Gazebo_SL_Bus_gazebo_msgs_LaserScan
Gazebo_SL_Bus_gazebo_msgs_LinkState
Gazebo_SL_Bus_gazebo_msgs_Point
Gazebo_SL_Bus_gazebo_msgs_Pose
Gazebo_SL_Bus_gazebo_msgs_Quaternion
Gazebo_SL_Bus_gazebo_msgs_Time
Name Complexity Dimensions
angle_min eal 1
angle_max eal 1
angle_step eal 1
range_min eal 1
range_max eal 1
count eal 1
vertical_angle_min eal 1
vertical_angle_max eal 1
vertical_angle_step eal 1
range eal 640
intensities eal 640
Simulink.BusElement: intensities
Properties
Name: intensities
DataType: double
Data Type Assistant
Mode: Built in
double
Data type override: I
Complexity: real
Dimensions: 640
DimensionsMode
Minimum: []
Maximum: []
Unit:
Description:
IsVarLen=1
Revert
Help
Apply

```m
function [valoreMinimo, posizioneMinimo, psi] = fnc(vettore)
%funzione per trovare la posizione dell'elemtento del LIDAR più vicino
%all'oggetto
valoreMinimo = Inf;
posizioneMinimo = 0;

% Iterazione attraverso il vettore
    for i = 1:length(vettore)
     % Controllo se l'elemento è diverso da zero e minore del valore minimo attuale
        if vettore(i) ~= 0 && vettore(i) < valoreMinimo
            valoreMinimo = vettore(i);  % Aggiornamento del valore minimo
            posizioneMinimo = i;        % Aggiornamento della posizione del valore minimo
        end
    end

psi = (((2*pi)/640)*posizioneMinimo);


```



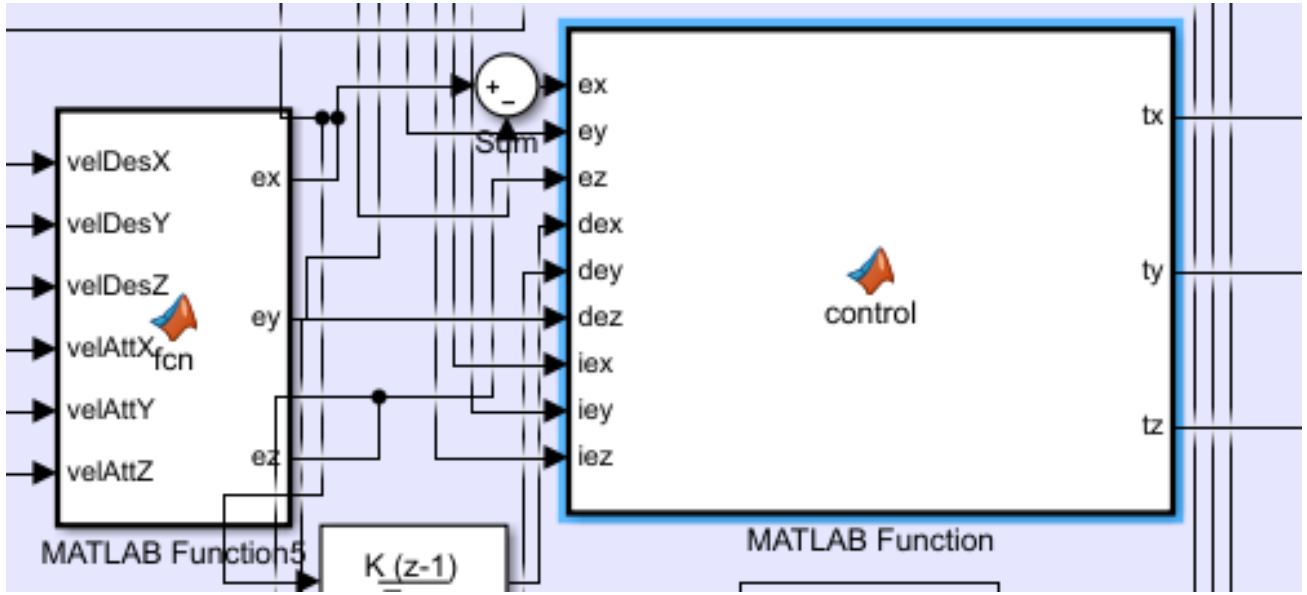


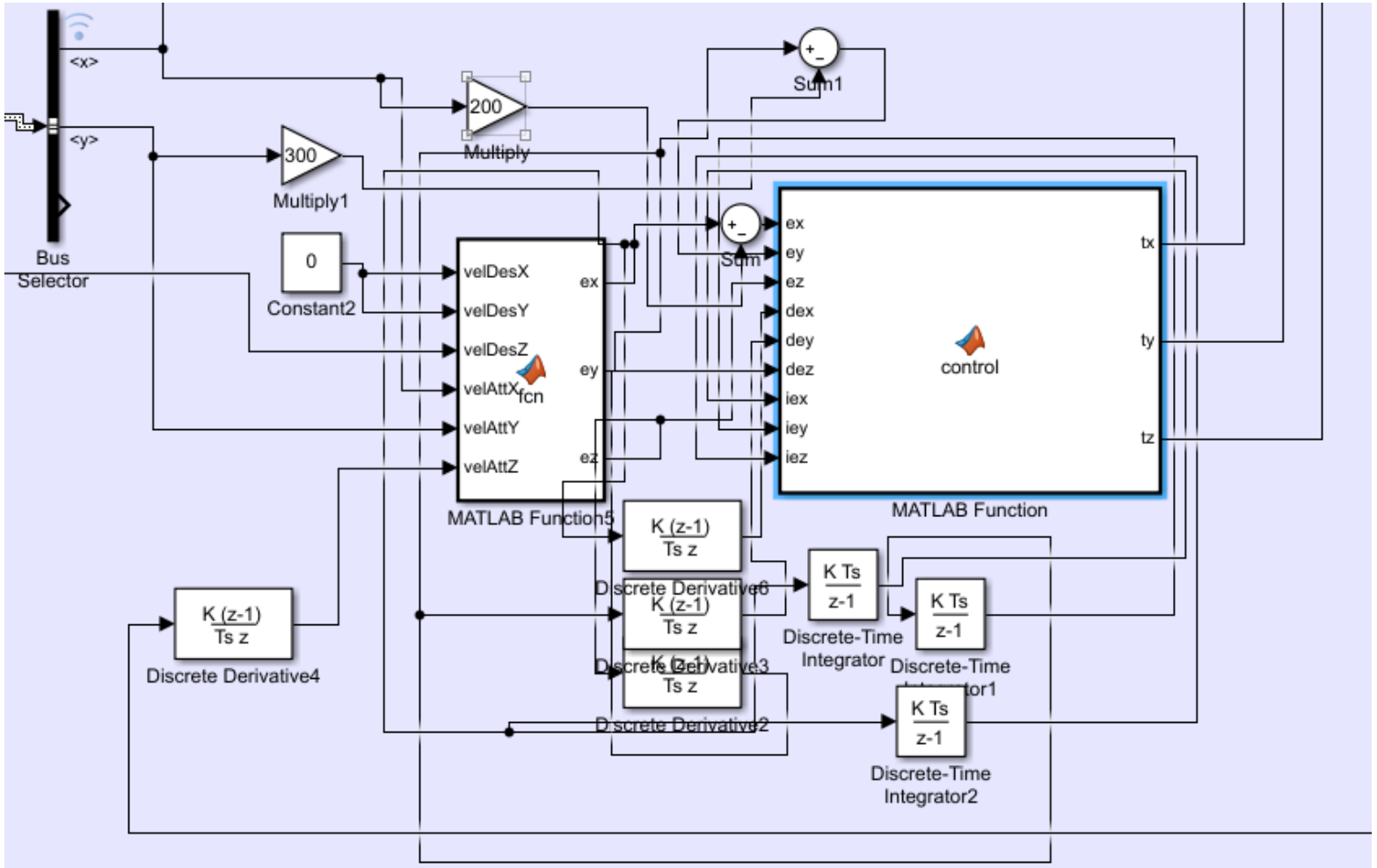



```
1   function  [yaw, pitch, roll] = fcn(x, y, z, w)
2   %trasforma quaternioni in angoli di eulero
3   quat=[x,y,z,w];
4   u = quat2eul(quat);
5
6   yaw = abs(u(1));
7   pitch = u(2);
8   roll = u(3);
```

```m
function [ex, ey, ez] = fcn(velDesX, velDesY, velDesZ, velAttX, velAttY, velAttZ)

ex = velDesX - velAttX;
ey = velDesY - velAttY;
ez = velDesZ - velAttZ;
```

```m
function [tx, ty, tz] = control(ex, ey, ez, dex, dey, dez, iex, iey, iez)

kp = 1;
kd = 0;
ki = 0;
tx = 5*(ex) + (kd*dex) + (ki*iex);
ty = 5*(ey) + (kd*dey) + (ki*iey);
tz = 20*(ez) + (kd*dez) + (ki*iez) ;
```

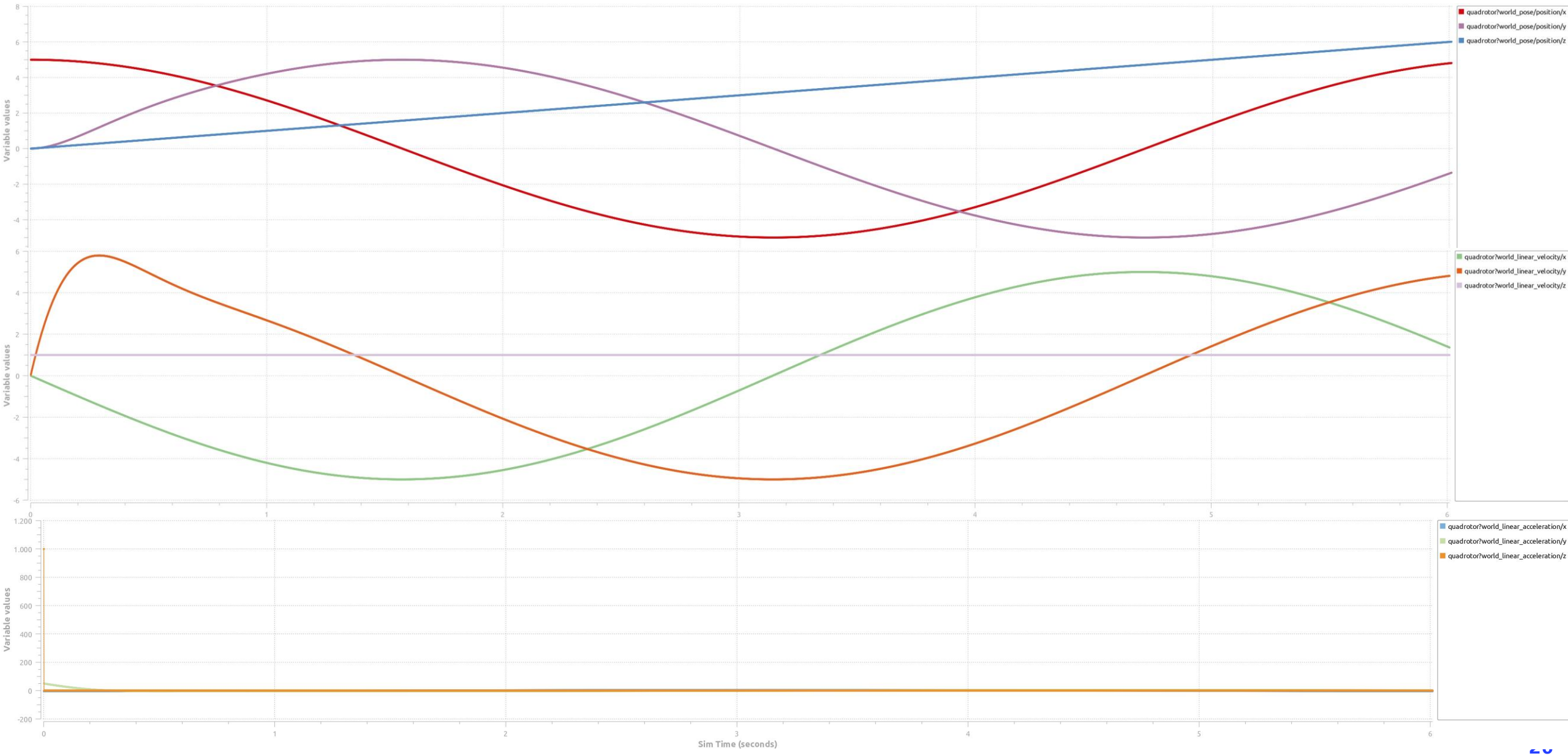



<x>
<y>
Bus
Selector
300
Multiply1
200
Multiply
Sum1
0
Constant2
velDesX
velDesY
velDesZ
velAttX
velAttY
velAttZ
ex
ey
ez
fcn
MATLAB Function5
Sum
ex
ey
ez
dex
dey
dez
iex
iey
iez
control
tx
ty
tz
MATLAB Function
K (z-1)
Ts z
Discrete Derivative6
K (z-1)
Ts z
Discrete Derivative3
K (z-1)
Ts z
Discrete Derivative2
K (z-1)
Ts z
Discrete Derivative4
K Ts
z-1
Discrete-Time
Integrator
K Ts
z-1
Discrete-Time
K Ts
z-1
Discrete-Time
Integrator2

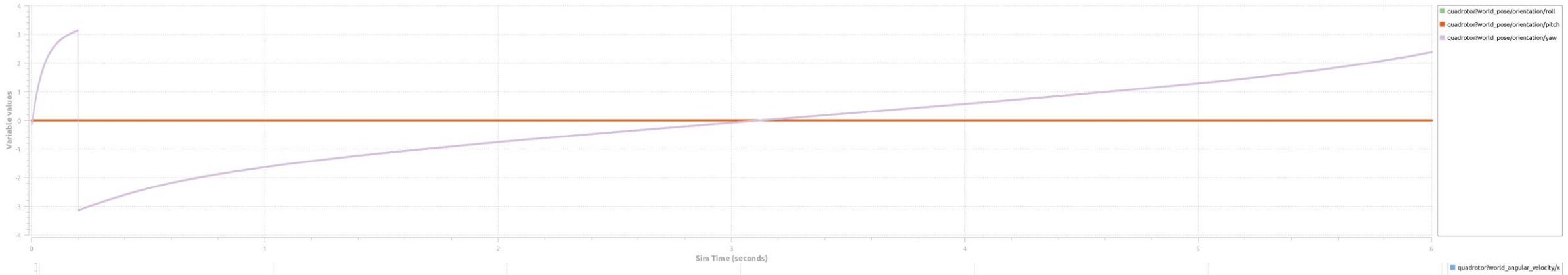
SIMULAZIONE E RISULTATI

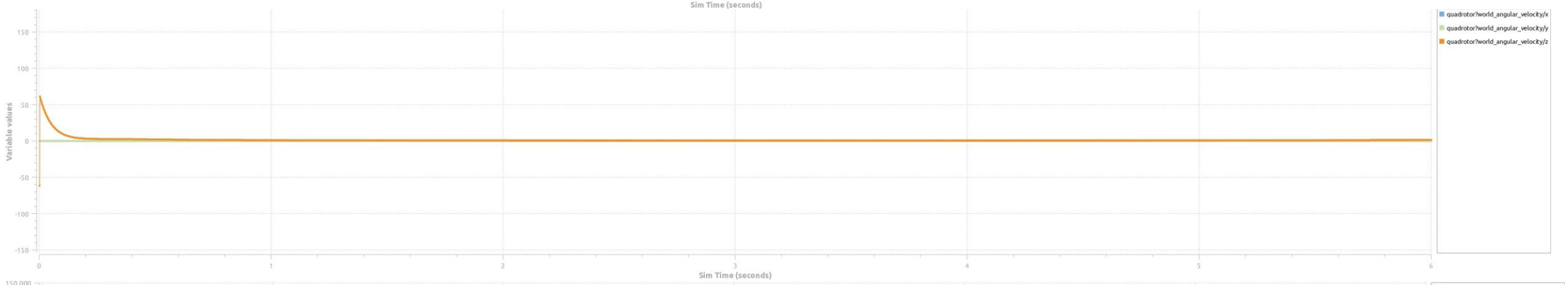
Video eliminati

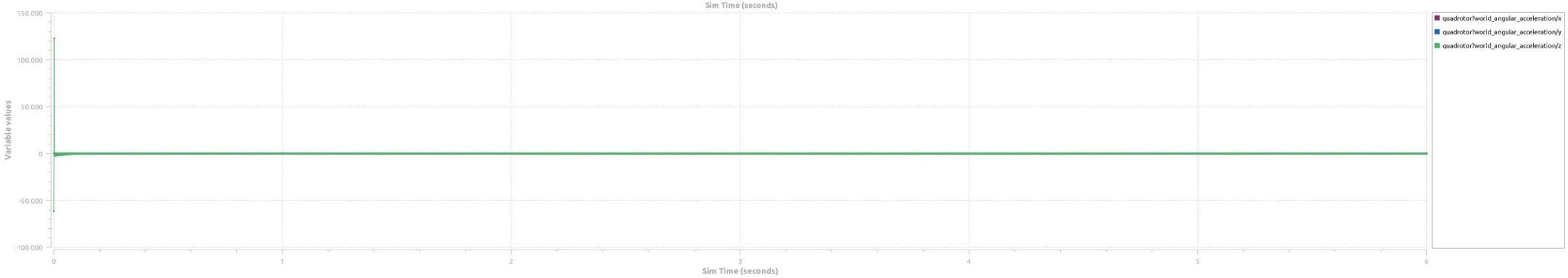
Grafici posizione, velocità e accelerazione lineare
Velocità sull'asse z: 1 m/s



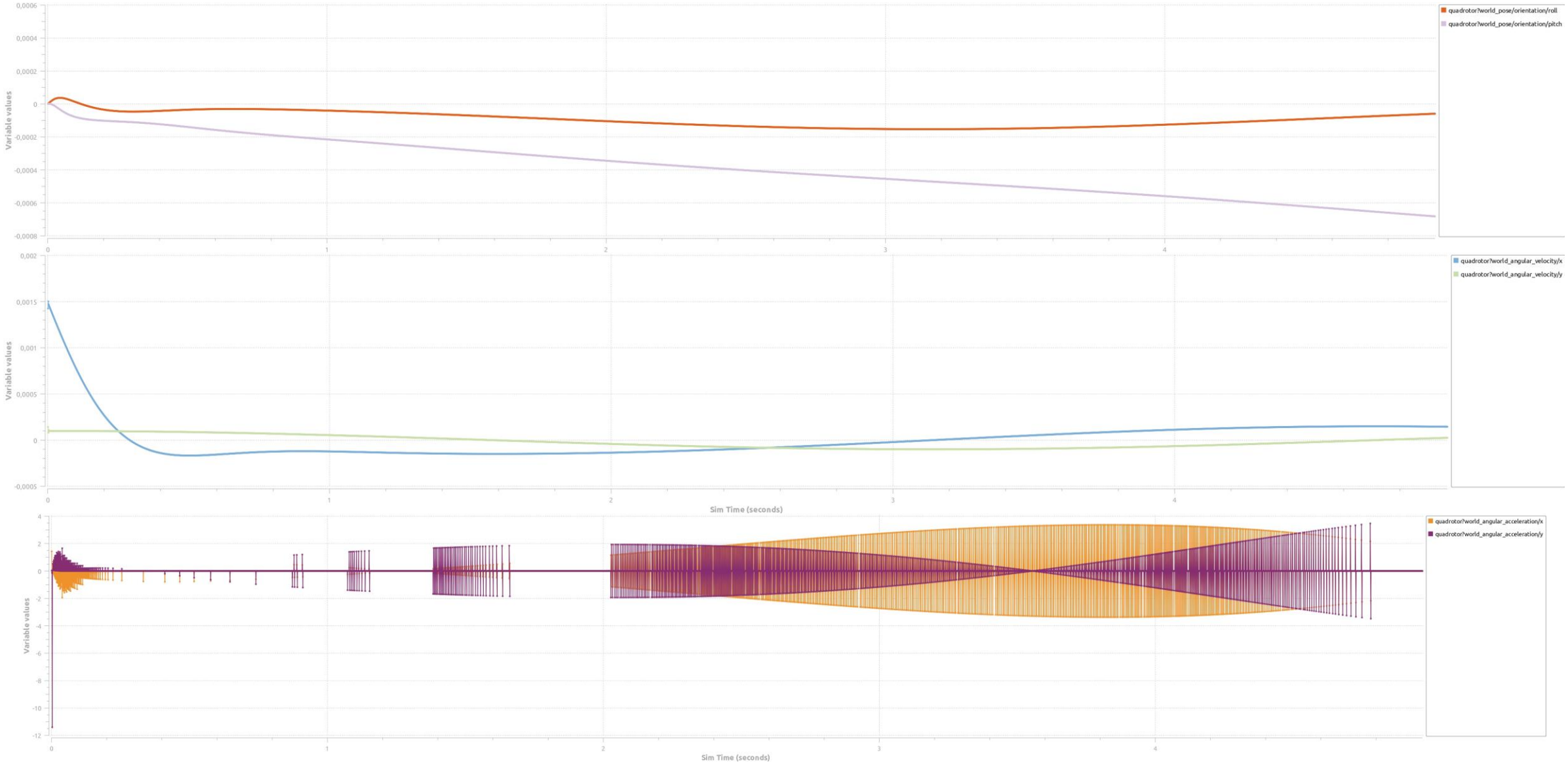
Grafici posizione, velocità e accelerazione angolare



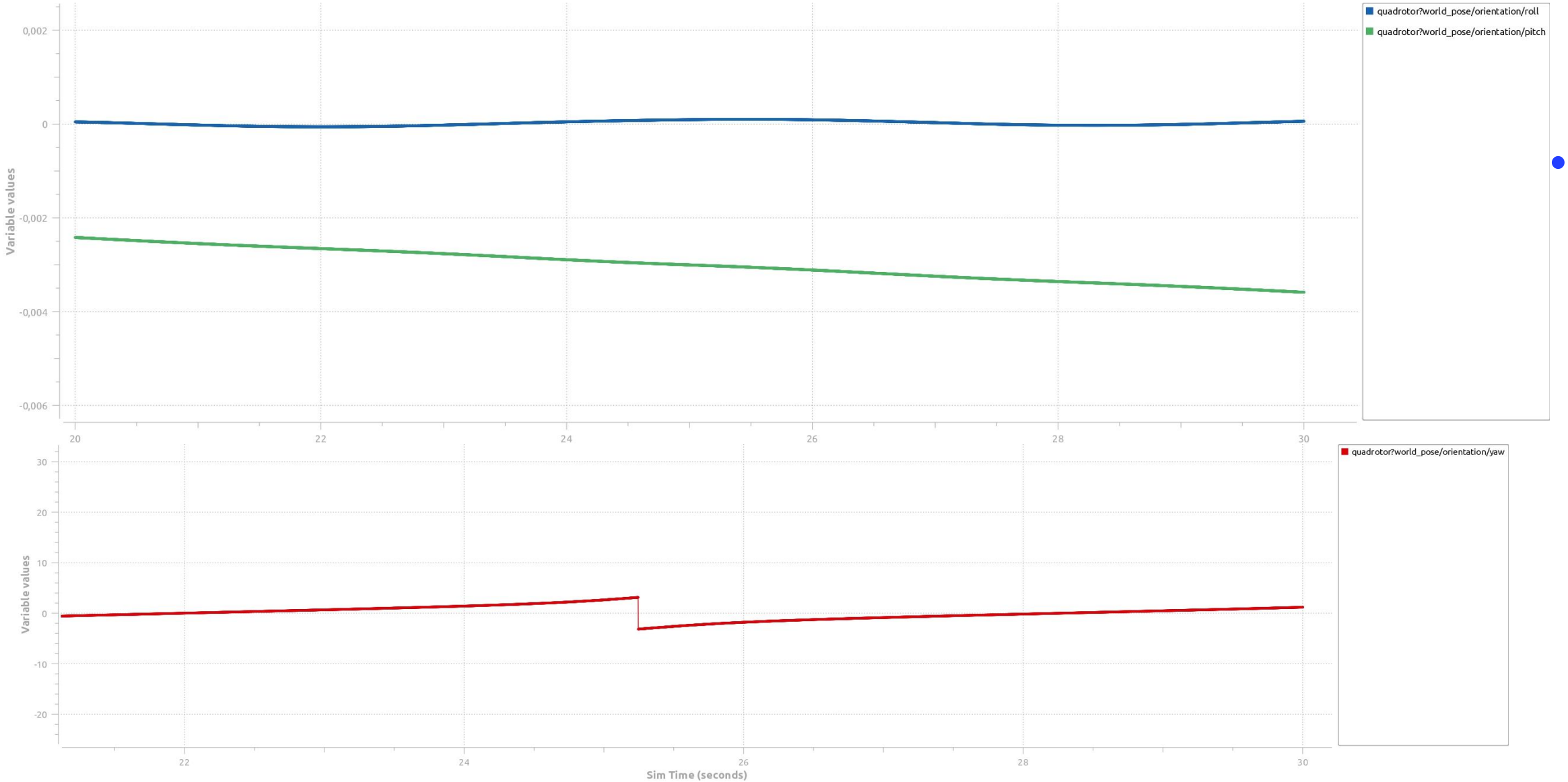




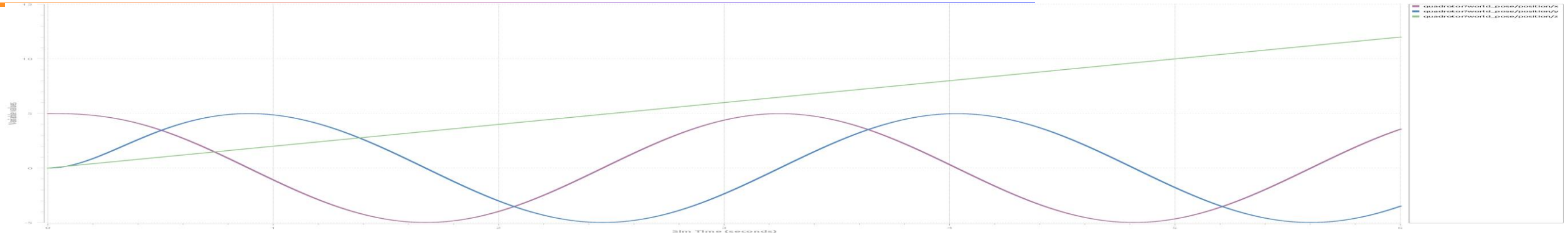
Grafici posizione, velocità e accelerazione angolare di roll e pitch

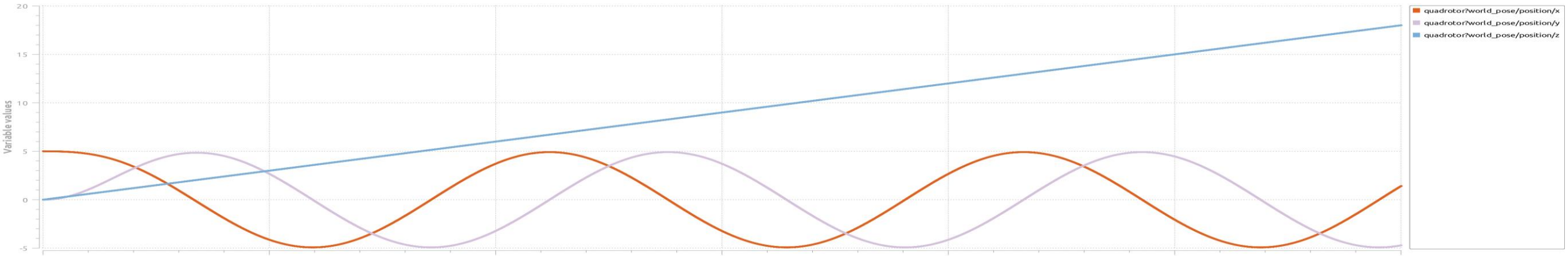


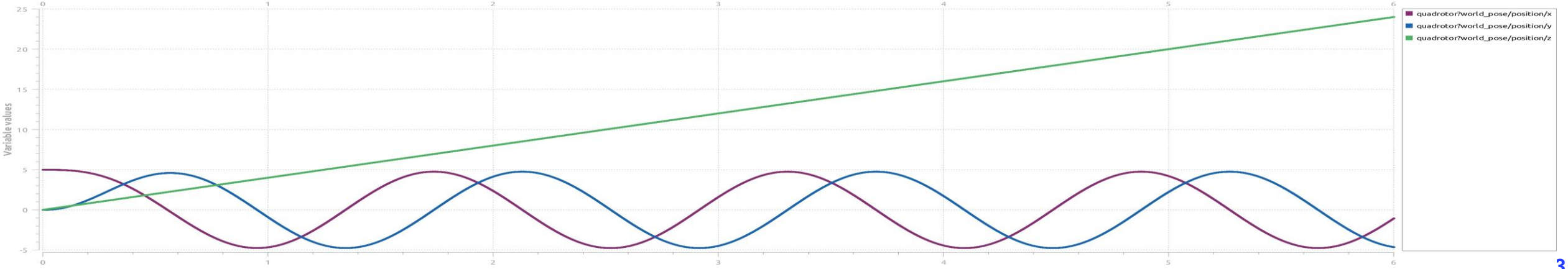
Grafici posizione di roll, pitch e yaw: 30 s



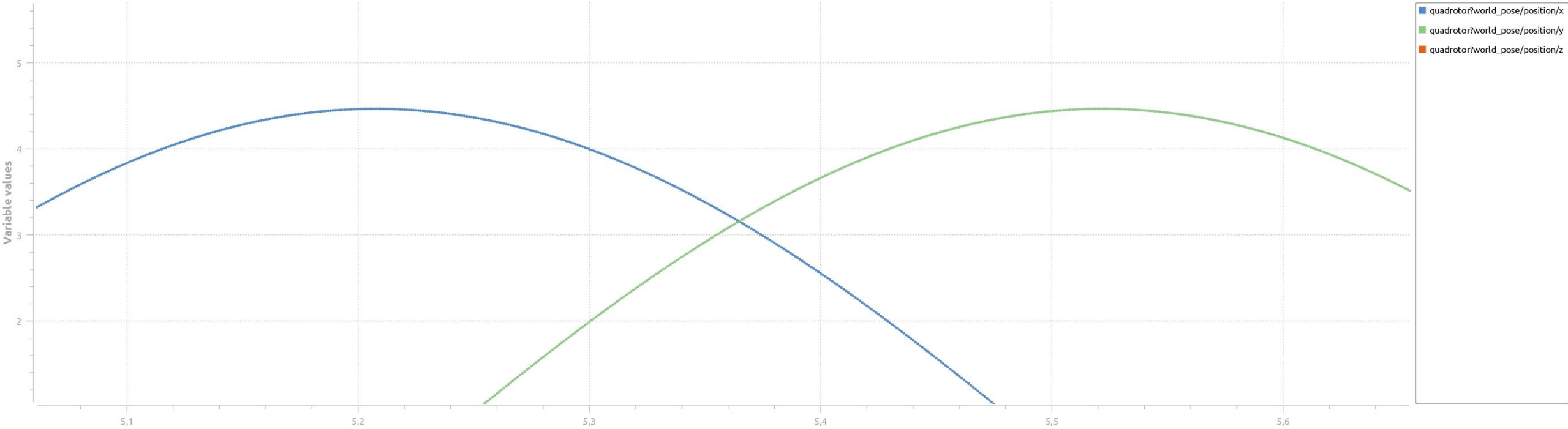
Grafici posizione x, y, z : velocità 2, 3, 4 m/s



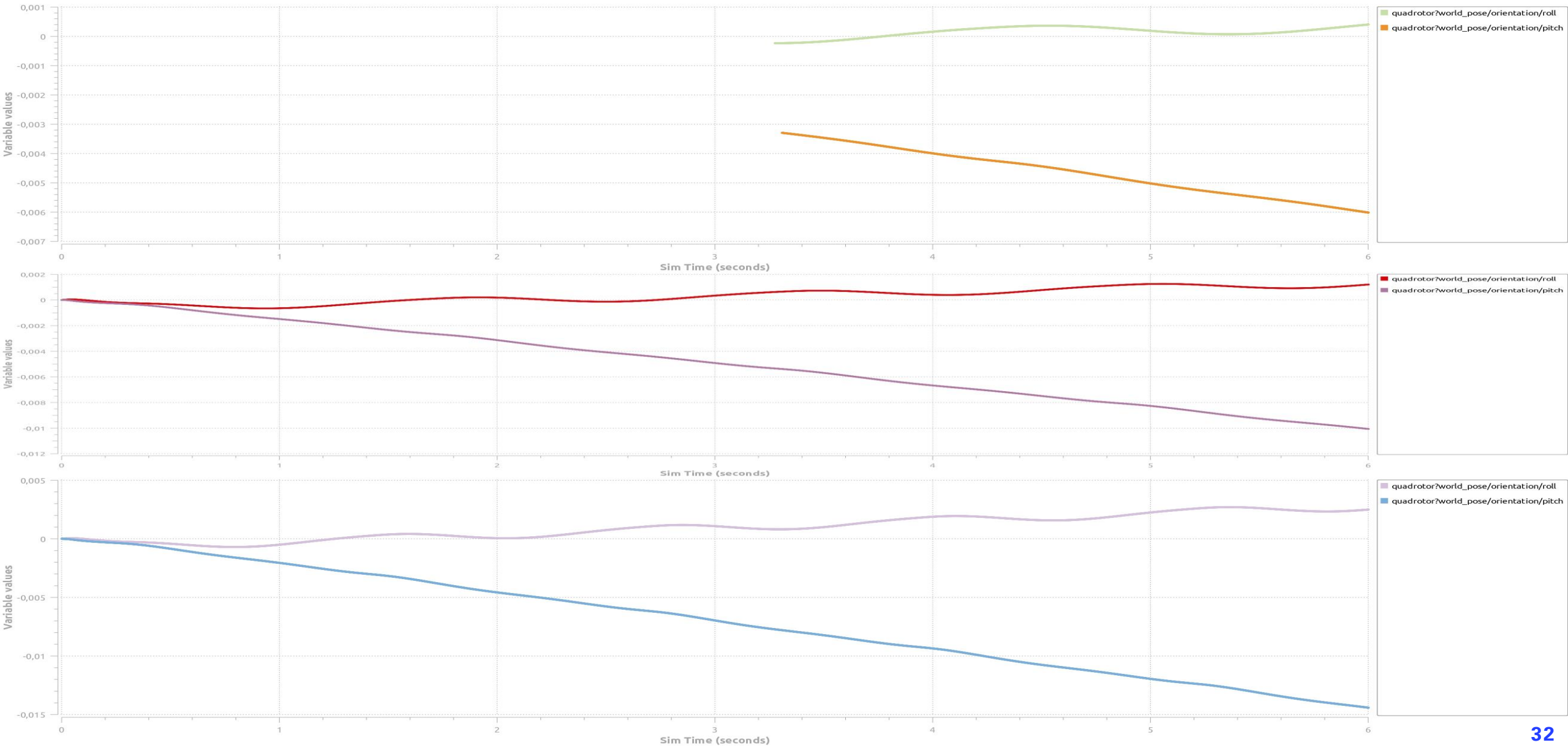




Grafici posizione x, y, z : velocità 5 m/s

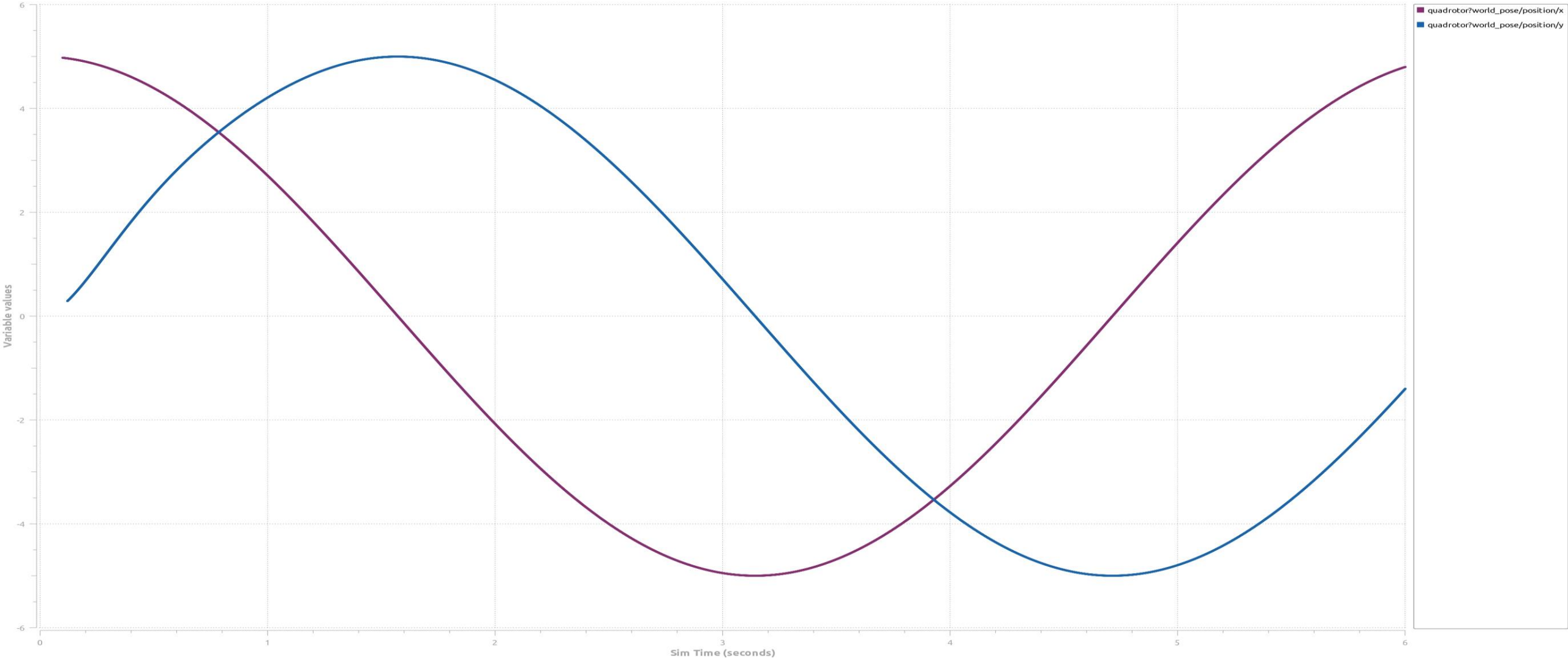


Grafici posizione pitch e roll : velocità 3, 4, 5 m/s

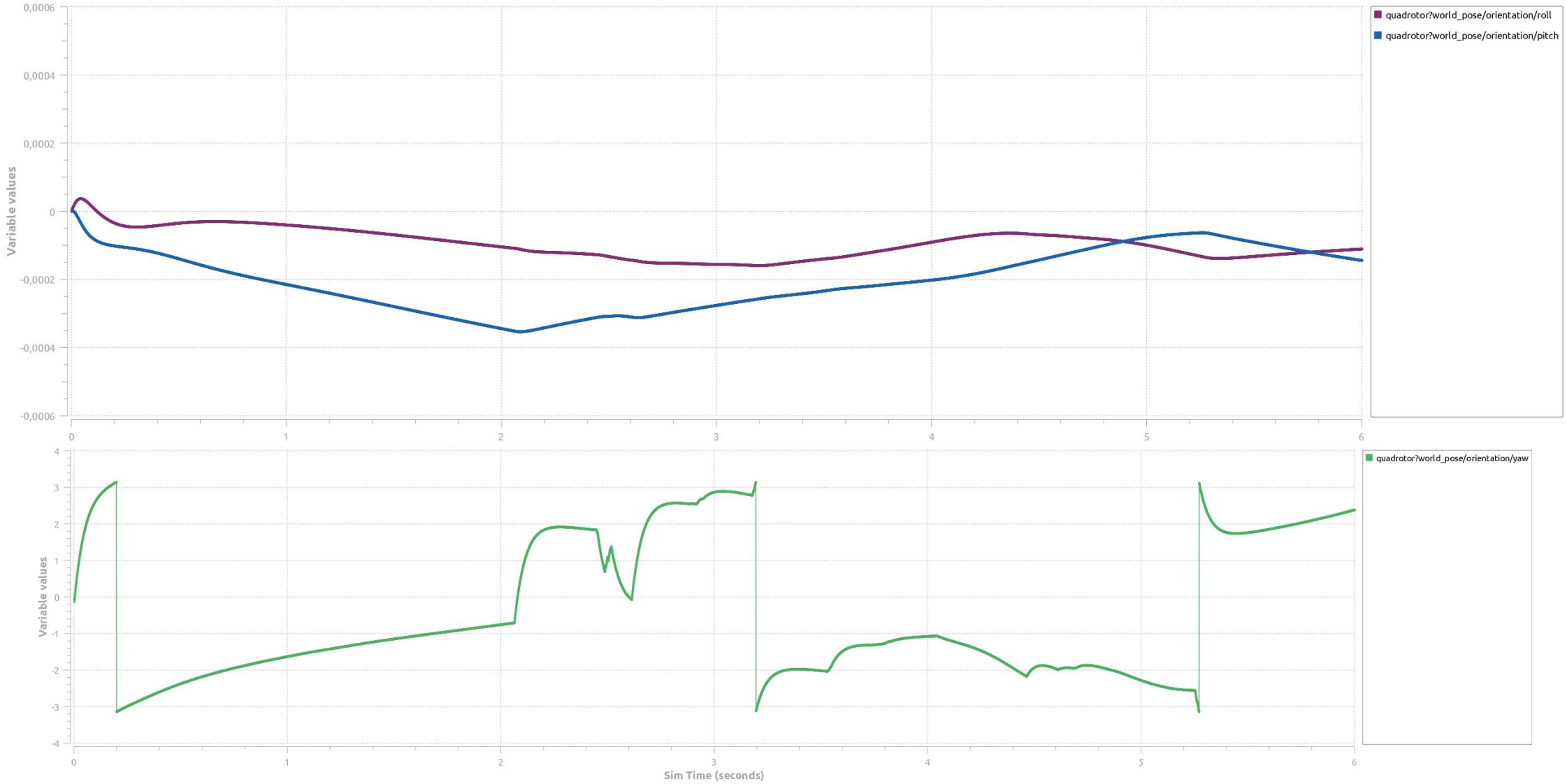


Video eliminati

Grafico posizione lineare x, y: velocità 1 m/s, 6 s



Posizione angolare di roll, pitch e yaw



APPLICAZIONI E POSSIBILI ESPANSIONI NEL FUTURO

- Applicazioni:
  - Rilevamento degli oggetti in una determinata traiettoria
  - Controllo di una struttura

- Possibili espansioni:
  - Miglioramento della traiettoria per evitare ostacoli
  - Mappatura 3D di un luogo tramite LIDAR

GRAZIE PER L'ATTENZIONE